ICEF14 – BOOK OF ABSTRACTS

23rd, October 2023

ICEF14 Proceedings

Message for ICEF14 Organizing committe

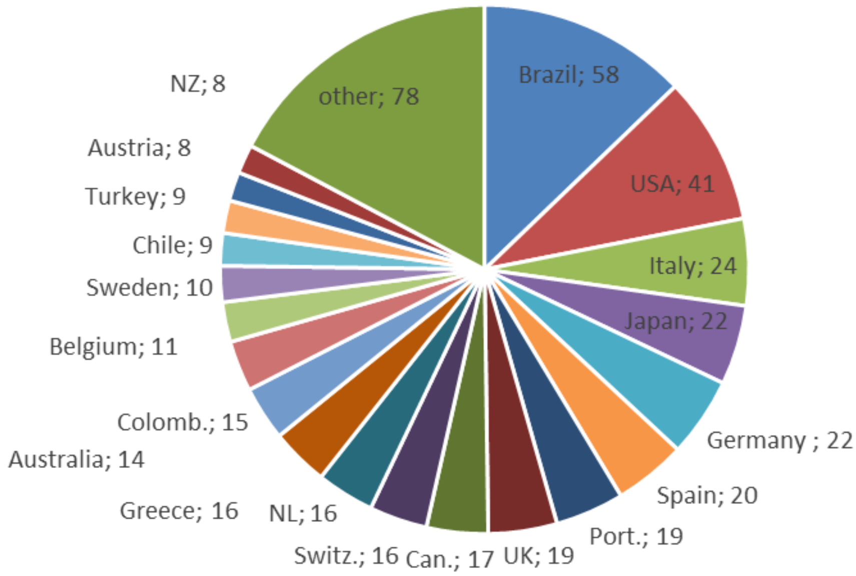
The ICEF14 congress took place in Nantes from June 20 to 23, 2023 and brought together 630 international participants around the theme:

"SUSTAINABLE FOOD MANUFACTURING FOR A RESILIENT FOOD CHAIN".

You will find at follow the proceedings of the congress gathering the oral and posters abstracts submited and presented during the congress.

➔ **Few words about ICEF14**

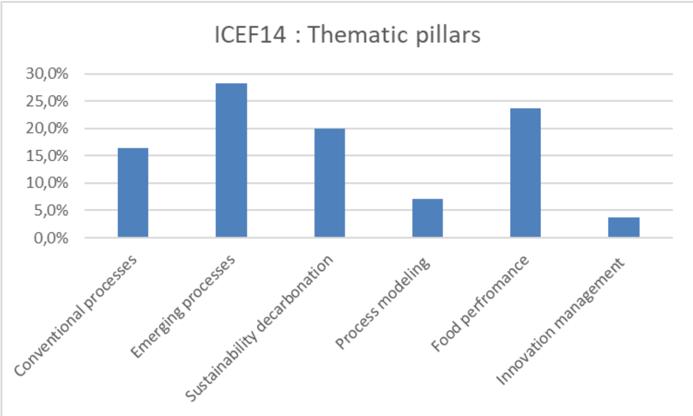
The 14th International Congress on Engineering and Food (ICEF14) is presented by the International Association for Engineering and Food (IAEF) with the support of ONIRIS - GEPEA (CNRS Research Unit 6144) and INRAE. The ICEF congress is held every 4 years and is the leading international scientific event on food processing. This is the second time ICEF has been held in France, following ICEF9 in Montpellier in 2004. In the Pays de la Loire region, of which Nantes is the capital, 1/3 of jobs are food-related. Along with neighboring Brittany, it is Europe's 9th-largest food-processing economy.



Nationalities of the participants of ICEF14 (non including 177 French participants)

Participation was highly international, as the graph above shows. A very strong French representation (177 participants or 28%) was followed by a strong Brazilian delegation, which can be explained by the strong links between Oniris and several Brazilian universities.
The ICEF14 congress lasted 3 and a half days, and was preceded by the "Young Scientists Workshop" organized on Monday afternoon June 19 to help PhD students and recent graduates prepare for their future careers and develop their networks.
A total of 750 papers were presented, with 250 oral presentations spread over 6 parallel sessions, including 8 plenary presentations. The remaining 500 papers were presented as posters in 2 sessions.
In addition, 4 technical visits were organized: the ALGOSOLIS platform of UMR GEPEA on the production and bio-refining of micro-algae, a joint visit to ONIRIS-GEPEA and the INRAE center in Nantes, a visit to AGRONAUTE in Nantes on the theme of urban agriculture and the circular economy, and the "MAD4AM" 3D printing cluster at Hall 6 in Nantes.

The congress was organized around 6 thematic pillars presented below. 4 of these pillars were particularly in demand: conventional processes, emerging processes, sustainability and decarbonization, and food performance. From the wide range of papers presented, it is difficult to extract any particular highlights. With regard to emerging processes, there was a great deal of activity around electrothermal processes, giving access to the decarbonization of the agri-food chain with heating processes (microwaves, ohmic heating, etc.), but also a wide variety of electrotechnologies enabling the development of improved structuring or preservation strategies (pulsed electric field, electric field, magnetic field, plasma, etc.). Among emerging processes, 3D printing was strongly represented, with around 30 oral communications (over 10% of the total); approaches are becoming increasingly sophisticated to customize matrices, while efforts are continuing to increase equipment productivity, following the example of research carried out at GEPEA on continuous ohmic heating in 3D printing. Food performance covered a wide range of presentations, from formulation to structuring and sensory perception. The implementation of new protein supplies, particularly via legumes, is often approached with nutritional (bioavailability), sensory and consumer acceptability issues in mind.



Invited plenary speakers addressed the following topics:

On Tuesday morning, two introductory lectures focused on food quality and the degree of food processing, with Isabelle SOUCHON (France, Agroparistech) "Healthy diets and food processing level: some research issues for food engineering" and Vincenzo FOGLIANO (NL, WUR "The link between food processing and food quality: can we go beyond the obvious?"), who presented cross-cutting views on the degree of food processing and "ultra-processing". Various models were presented by I. Souchon, who emphasized that progress still needs to be made and that these models and classifications are often interpreted too quickly by consumers; the processing of agricultural raw materials, cooking and stabilization are still necessary. V. Fogliano used a number of examples to show that the speed with which food is ingested has a significant influence on certain nutritional indicators; in other words, foods requiring longer chewing and slower digestion would have a more favorable nutritional outcome, associated with less body weight gain.

These two presentations were followed by Judith EVANS (LSBU, UK "The role of refrigeration in creating a secure, sustainable and resilient food chain") and Sara GONZALES-GARCIA (USC, ESP "Driving commitment to a sustainable food system: consumer and producer perspectives") who presented complementary approaches to the sustainability of food systems. Judith EVANS is President of Commission C of the International Institute of Refrigeration (IIF-IIR), covering food applications. The cold chain is a major challenge for preserving food resources and reducing waste; these topics are currently being investigated in the European "ENOUGH" project, which has been selected for the 2020 European GREENDEAL call for proposals. Agricultural sectors were detailed by S Gonzales, who is completing the coordination of a European project on this subject; agriculture is facing major challenges in terms of machinery and fertilizers, challenges that legumes can help to overcome in part through their ability to fix atmospheric nitrogen.

On Wednesday June 20, two further plenary lectures were given on process-structure links. Thijs DEFRAEYE (ETH Zurich "Physics-based modeling for cooling and drying of plant-based foods: today, tomorrow and beyond") highlighted the value of modeling for optimizing processes and integrating these models into supervision and predictive cold chain tools. He also presented recent advances in electro-hydro-dynamic (EHD) drying, a well-known process which he revisited and to which he introduced interesting innovations enabling its implementation on an industrial scale while reducing energy consumption. Osvaldo H. CAMPANELLA (USA, "Fabrication, characterization, and potential applications of texturization of biopolymers to produce nutritious and high-quality food products") presented a detailed review of the state of the art in polymer structuring and shaping processes, with a particular focus on plant proteins; the subject of plant protein-based analogues of meat or dairy products was the subject of numerous presentations throughout the congress, using a variety of sources (legumes, insects, microalgae, ...) and was one of the highlights of ICEF14.

Finally, at the close of the congress on Friday June 23, Prof. Weibiao ZHOU from Singapore illustrated the importance of the links between structure and the functional and nutritional properties of foods; he has developed numerous projects around bread-making with a view to enriching the nutritional value of these products. Pierre WEILL, an agricultural engineer, entrepreneur and doctor in biological sciences and nutrition, presented the "Blanc-Bleu-cœur" association, which combines animal feed and the nutritional quality of dairy products in particular, by optimizing the supply of unsaturated fatty acids (□3, □6) throughout the processing chain from plant to human.
At the close of ICEF14, 5 "best oral" and 6 "best poster" awards were presented to students. 8 "IAEF Life Time Achievement" awards were presented by IAEF in recognition of significant contributions to the field of agri-food processes, and the date and venue of the next ICEF were announced: ICEF15 will take place in April 2027 in Orlando, Florida, USA.

To conclude this overview of the ICEF14 congress, we would like to thank the members of the local organizing committee for their efficient work, the scientific committee, the administrations of ONIRIS, GEPEA CNRS 6144 and INRAE, the Pays de la Loire Region, Nantes-Métropole, the Cité des Congrès de Nantes, our sponsors EHEDG, Anton-Paar, FLUID-AIR, ThermoFisher Scientific, ELSEVIER, Nestlé, FARHAT Bakery, our exhibitors SAIREM and HYPERBARIC, our "Best Orals" sponsors PURATOS, Qualiment, SYMRISE, MAD4AM Cluster/GEPEA and our "Best Posters" sponsors ONIRIS-GEPEA CNRS 6144 and INRAE. Our thanks also go to INSIGHT-OUTSIDE for their support in organizing ICEF14, and to "La Maison HEBEL" for the quality of the catering, which contributed for a significant share to the success of ICEF14 thanks to a high quality French Cuisine.

ICEF 14 PROCEEDING

The proceedig proposes a suite of abracts with the following agenda

Conventional processes including refrigeration, drying, thermal, mechanical etc

Emerging processes & hurdles technologies

Process modelling up/down scaling

Food performances, properties, digestibility & functionalities

Food future, innovation in teaching and learning, innovation and management

Special Session Fouling & cleaning

Special Session; HPTP, state of the art and its future in the food industry?

Special Session Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Special Session Plant proteins

Special Session Thermal processing & optimization

Special Session Training & Digital

Special Session Digital foods

Special session – others

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Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Modelling of pore development during drying of viscoelastic food materials

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In Literature, there is poor understanding why food materials get porous during drying [1] and we aim to provide a mechanistic explanation for the pore development, based on a multiphysics model, describing a) heat/mass transfer during drying, b) drying-driven mechanical stress development of the food material, and c) viscoelastic relaxation.
We target both cellular food materials and homogeneous foods.
We assume that food matrix behaves as a hydrogel. Pre-existing pores (as intercellular spaces) are assumed to be very small, spherical, gas-filled bubbles exchanging water vapour with the matrix. We also study the impact of an elastic skin on the drying process.
The problem is described by a set of coupled PDE equations, which are solved within a finite element code [2].
The model shows that during drying, the food matrix shrinks, but also tensile stresses are generated – which lead to enlargement of pores, and thus to increase of porosity. This effect is enhanced when an elastic skin is present. It can also explain the effect of case hardening on pore development, leading to the development of a stiff elastic skin if the material gets near the glass transition.

Similar phenomena happen during drying of maltodextrin solutions with high molecular weight. Their rheology has been fully characterized recently [3], showing viscoelastic behaviour. It is observed that pore formation happens during drying if an elastic skin is formed via gelation during drying [4-5]. This example allows us to extend the model to viscoelastic materials.

The multiphysics model is very novel to the field of food engineering, and presents large potential such as describing food structure development in osmotic drying, freeze-drying or vacuum drying, or other food structuring methods involving intensive heating like frying, baking, microwave heating, extrusion.

[1] Nguyen T.K. et al. Food Research International 103 (2018): 215-225.
[2] Curatolo M. et al., Soft matter 14 (2018): 2310-2321.
[3] Van der Sman R. G. M., et al. Food Hydrocolloids 124 (2022): 107306.
[4] Siemons I., et al. Food Research International 131 (2020): 108988.
[5] Jin, Xin, and R. G. M. van der Sman. Food Structure 32 (2022): 100269.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Unraveling the influence of convective drying on vegetable seeds

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High-quality seeds are the starting point for successful agricultural plant production and for most of our food, hence they have an impact on the sustainability of our food production. Vegetable production is an important industry, facilitating the trend towards more vegetarian and healthy diets. Seed breeding companies are challenged by producing high-quality seeds for farmers and keeping the quality constant to assure healthy plants and high yields. Therefore, throughout the seed production process, many dedicated treatments and drying steps are applied. While hydrating treatments are well investigated, drying treatments have not yet been intensively studied. In particular, the specific effects of drying on seed properties, storability and germination, as well as optimal drying routes are largely unknown.

This project aims therefore at quantification of the influence of convective drying on vegetable seed quality. In our experimental and modelling studies we investigated the drying kinetics as well as the evolving moisture gradients and porosity in seeds during convective drying and we hope to link those to predictions of seed quality. We focus on a single seed level of spherical shaped cabbage seeds before investigating bulk seeds in fluid bed drying.

A model based on heat and mass transfer including independently determined isotherms and diffusion coefficients was developed to predict drying kinetics for different drying conditions with varying temperature and relative humidity of the air. For validation of the model we employed a custom-built small-scale dryer in combination with in-line measurements and controlled air conditions, as well as advanced imaging techniques like MRI and XRT for in-line observation of development of moisture gradients and structure. Our results show that the model successfully predicts the drying kinetics of cabbage seeds and with MRI and XRT we could accurately map evolution changes in porosity of drying seeds. In a next step the drying behaviour will be related to seed quality constraints, i.e. germination and glassy state.

Ultimately, these models will be employed to optimise drying regarding efficiency while adhering to quality constraints. This approach can contribute to new best practices in industrial seed drying and hence provide more sustainable and long-lasting high-quality seeds.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Microwave hydrothermal treatment of chickpea seeds: mass transfer dynamics

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Keywords: Mass transfer kinetics ; microwave ; hydration-cooking ; chickpea seeds.,

In the context of legume consumption, the preparation of these dry whole seeds, such as chickpeas, relies on key hydration and cooking operations. These operations require a more or less long time depending on the conditions: soaking at room temperature followed by cooking, soaking and cooking simultaneously, with or without pressure. During the soaking of seeds, water absorption is the main mechanism inducing swelling and changes in physical characteristics, beyond a temperature of 55°C, water absorption is accompanied by changes in starch granules, via the initiation of gelatinization mechanisms and can lead to a significant loss of soluble solids. Microwave treatments can accelerate the mass and heat transfer process. The present work aims to study the mass transfer kinetics during the microwave hydration-cooking step of chickpea seeds in excess of water under different conditions (400, 800 and 1200 W), in comparison with the conventional cooking on electric plate. Chickpea seeds are assimilated to a sphere (sphericity = 0.87; equivalent diameter = 9.5 mm; specific convective heat exchange surface = 310 mm^2). The results show that the water uptake kinetics are different depending on the type and conditions of the treatment applied. The water content of the seeds increases monotonically for the conventional and microwave (400W) treatments. For microwave treatments at high powers (800 and 1200W), the water content increases rapidly, then stabilizes around a maximum value and then decreases slightly. Losses of soluble solids increase during the cooking process. An increase in microwave power leads to higher losses. Changes in physical characterizations of the seeds are in agreement with the mass transfer results. A temperature gradient hypothesis is assumed to describe the unexpected pattern of water uptake kinetics for high microwave power treatments, associated with volumetric heating by electromagnetic waves. During the treatment, the core temperature of the seeds could exceed 100°C and induce changes in the seed core structure, while the seed surface remains at stable around 100°C, in contact with boiling water. These modifications could modify the mechanisms of water transfer from the surface to the core classically. These hypotheses must be confronted with modelling and numerical simulations.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Microstructural analysis of frozen raspberries using X-ray microtomography: a comparative study with quality changes.

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Quality properties of frozen foods are strongly related to the product microstructural organization such as ice crystal structures. Ice crystals characteristics are defined both by the freezing process and the frozen storage conditions. For example, fluctuating storage temperatures cause ice crystals growth by recrystallization, leading to tissue damages and subsequent quality losses. Microstructure imaging techniques such as X-ray microtomography could be useful for a better understanding of the complex mechanisms that take place at the microscopic level in order to reduce macroscopic quality changes during frozen storage.
Raspberries are known for their health benefits but they are difficult to preserve for a long time. Freezing process is usually used to increase their shelf life, but these fruits are highly sensitive and encountered freeze damages.

In this work, X-Ray microtomography was used to investigate microstructural changes occurring during freezing and storage of raspberries under different conditions. The fruits were imaged directly at the frozen state thanks to a cooling stage (-20°C). The analysis of X-ray images showed ice crystal growth with storage temperature, temperature fluctuations and storage duration. Quality parameters, such as texture and drip loss, were also measured. Raspberries texture, along with drip loss, was altered by freezing and during storage, probably due to cell perforation caused by ice crystals formation and growth. These results taken together, show how microstructural changes can affect macroscopical quality parameters.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Microstructure evolution during deep frying and its impact on material properties

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During deep frying several multiphysical processes take place simultaneously. Therefore, a coupled model involving heat and mass transfer with mechanical deformation is necessary to understand and optimize the process. It has previously been observed that the porous microstructure plays an important role in oil uptake, however, few studies have investigated the influence of deforming microstructure on critical material properties necessary for the model. The purpose of this study was to explore the relationship between structure parameters (porosity, tortuosity) and material properties (permeability, young's modulus) relevant to the deep frying process. Native starch (potato and wheat) and wheat gluten samples with varying hydration levels were fried in perforated teflon tubes. High resolution in situ synchrotron X-ray µCT was used to characterize the change in 3D porous microstructure with time. The different phases (starch/protein, oil, and air) were segmented to separate the pore space from the solid microstructure. Multiple regions of interest (ROI) in the pore space were selected to build a pore network model (PNM) and using Darcy's law in fully saturated porous media, intrinsic permeability was evaluated. Directional open porosity of the ROIs was used to establish a structural relationship for permeability based on the Kozeny?Carmen equation. The solid microstructure of the same ROIs was converted to faceted geometry to evaluate the bulk modulus using FEM.
The initial moisture content greatly affected the changes in microstructure over the course of the process, with noticeable deformation in higher hydration samples. On comparing the intrinsic permeability from the PNM on various ROIs, it was found that that the correlation between absolute permeability and open porosity was greatly influenced by heterogeneous structure of the porous matrix. From the deformation analysis it was revealed that the structure thickness and pore morphology are crucial parameters affecting young's modulus.
The results further support the importance of accounting for microstructural changes and the associated impact material property. The information from this study will be used as the basis for evaluation of fluid specific relative permeability to model the fluid flow as compared with in situ imaging of during the deep frying process.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Numerical design and use of a portable probe for the identification of mechanical and mass transport properties within fermenting food matrices: application to semi-hard cheese

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The monitoring of semi-hard cheese ripening is empirically based on manual inspection of the cheese blocks. Cheese manufacturers are demanding for new technologies to be used in ripening cellar and making it possible to follow the evolution of physico-chemical parameters for better following the ripening process. This study presents the multiphysic computer assisted design and experimental validation of a portable probe able to measure locally, at its tip: the dynamic viscosity, Henry's constant, the CO2 concentration, the CO2 diffusivity and production rate within a couple of hours with the use of only one probe.
The probe consists of a pressure sensor within a sealed cylinder that is plunged in a few millimeters of the food matrix. The cylinder is then swept using either CO2 or N2 and one or two impulses of pressure are generated. The pressure then decreases as a function of the ability of the matrix to absorb/transport the gas in a dissolved form and its ability to deform. Miscellaneous shapes of the tip of the probe were numerically investigated and optimized using a model previously validated (Laridon, et al., 2020).
The probe was experimentally validated on distilled water and a reference tar for the viscosity.
CO2 Henry's constant was identified using two pressure impulses. The measure gave a value of 3.5×10-4 mol.m-3.Pa-1 for a value of 3.8×10-4 mol.m-3.Pa-1 for pure water (Sanders, 2015). The diffusivity of CO2 was then measured at 1.5×10-9 m2.s-1 compared to a mean value of 1.8×10-9 m2.s-1 (Chaix, E, 2014). The viscosity of a reference tar was identified with 8% uncertainty at 20°C.
On semi-hard cheese, once Henry's constant was identified at 5×10-4 mol.m-3.Pa-1 the concentration of the CO2 solubilized in the core of a semi-hard cheese was measured at 25-26 mol.m-3. The diffusivity of CO2 was measured at 3.8×10-10 m2.s-1 for the semi-hard cheese under study.
Acceptable agreements were found between the measurements of the CO2 transport properties in both water and cheese as well as for the measurement of viscosities. Three improved prototypes are now tested in industrial conditions.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Modeling of the moisture sorption kinetics and humidity-induced collapse for freeze-dried products

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Freeze-drying/lyophilization is an essential technology for the production of stable dried pharmaceuticals with longer shelf life. Freeze-drying produces porous product with a large surface area and high hygroscopicity. Moisture sorption to freeze-dried products remains a problem through the processing and during long-term storage. It would be useful, for example, if a model gives possible waiting periods from the end of drying to the packaging, or shelf-life of a product in a package where moisture leakage cannot be completely avoided. Moisture sorption is governed by the glass-rubber transition of the freeze-dried matrix. Since this transition relates to the temperature and moisture content, the onset of transition is influenced by the balance between the fluidity of the matrix and the sorption rate. Therefore, a model strategy that relates the glass transition and moisture sorption kinetics to the humidity-induced-collapse is fundamental for quantitative prediction of the shelf-life of the freeze-dried products, but such a model has not yet been reported. This study is to develop a new mathematical model of sorption kinetics applicable to glassy freeze-dried matrices. By incorporating experimentally obtained moisture sorption isotherms and glass transition lines into the model development, it is shown that the time until the humidity-induced-collapse occurs can be predicted with higher accuracy. Results were visually summarized in stability maps as a function of the storage conditions, such as relative humidity and temperature. The location of the limit line, the border to induce humidity-induced-collapse, was observed to depend on the sorption rate constant, moisture sorption isotherm, and glass transition temperature of the selected material. As expected, matrices (i.e. freeze-dried maltodextrin with different DE values) with relatively high transition temperatures exhibited a wider stability zone. The mathematical model proposed in this study could be a robust tool for quantitatively predicting product stability against storage conditions that reflect the properties of materials.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Temperature distribution in a High Shear Mixer during heating

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For some type of products, for instance, sweet chili sauce, mayonnaise and curry mango sauce, the high shear mixer works as a batch pasteurizer. During the heating process, the rotor is normally kept still, while the agitators rotates to help speed up the heating process. Due to the complexity of the machine geometry, it is very difficult to find out the coldest region of the fluid through experimental measurement. In this situation, whether the whole domain of the fluid is heated to the targeted temperature with the given heating time is hard to know. This question could be answered through computational fluid dynamics (CFD) simulation, which is investigated in this study.
The theoretical calculation when compared to experiments indicate that the steam temperature and steam heat transfer coefficient are suitable as boundary conditions for viscous products because heat transfer coefficient on the product side is the main limiting factor. From the CFD simulations, the cold region in products locates around the corner of the rotor. The temperature of both products distributes evenly during heating process, which proves that chosen agitator speed is a good enough as rotational speed for heating. Therefore, cold region should not be an issue during heating inside the high shear mixer.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

The effect of dasher design on residence time and microstructure of frozen desserts produced with a continuous scraped surface freezer

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Most frozen desserts produced for retail sale are manufactured using continuous scraped surface freezers (SSFs). SSFs contain a dasher assembly which includes a dasher, knives, and sometimes a beater. The purpose of the dasher assembly is to mix the working fluid, scrape ice off the freezer wall as it forms, and whip air into the product as it is dynamically frozen. These processes occur simultaneously and impact the structure of the frozen dessert. Equipment manufacturers of SSFs employ a variety of dasher assembly designs based on desired product attributes; however, to date these assemblies have largely been constructed based on proprietary findings, and trial and error. Very little is known about how the dasher assembly impacts product structures, quality, and fluid behavior in the freezer. To improve the understanding of SSF operation, a continuous freezer was used in a series of pilot scale experimental studies encompassing 5 commercially available dasher assemblies with varying geometries and ranging from 11 to 57% volume displacement. Residence time distribution (RTD) profiles and microstructural attributes (ice crystal, air cell, and fat globule size distributions) were characterized for sorbet and ice cream made under constant processing conditions, while varying dasher assembly. For selected dashers, we also investigated how processing parameters, (including product throughput, dasher rotational speed, and overrun), interact with dasher design to influence RTD and microstructural attributes. Generally, increased volume displacement of the dasher assembly resulted in a shorter RTD in sorbet. There was a small effect of dasher design on ice crystal size in sorbet, with dashers delivering a shorter RTD generally producing smaller ice crystals. In ice cream, dasher design played a larger role in structure formation as its microstructural components are more strongly affected by the shear each dasher generates. This study furthers our understanding of how dasher design influences heat transfer and shear forces in SSFs and will enable frozen dessert manufacturers to select a dasher based on desired structural characteristics.

Oral

Future cheeses produced by extrusion of renneted curds

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Objective: The possibility to structure milk curds by extrusion, in order to create cheeses with customized properties in terms of texture and meltability has not been studied. Hence, the aim of this study was to investigate the shearing process of renneted curds in a twin-screw extruder, and understand the effect of the extrusion parameters on cheese composition, structure and texture.
Methods: A lab twin-screw extruder with a cylindrical cooling die was used for the shearing process. Four parameters at two levels were selected: heating temperature (Th, 80 or 90 °C), screw speed (SP, 50 or 150 rpm), barrel length (L, half or full) and cooling temperature (Tc, 10 or 30°C). Residence time (RT) and specific mechanical energy (SME) were calculated. Exit temperature (Texit) of the extrudates was measured at the exit of the cooling die. The effect of controllable parameters (Th, SP, L and Tc) on measured and calculated parameters (SME, Texit and RT) and curd properties (water content and distribution, textural properties – elasticity and melt strength, and microstructure by X-ray micro-computed tomography) were evaluated.
Results: Extruded curd products with a variety of properties were obtained, which were significantly influenced by controllable extrusion parameters Th and Tc. A higher Th enhanced curd elasticity and reduced melt strength while a higher Tc induced lower water content (42.8–48.6%) and melt strength. The measured and calculated parameters could comprehensively summarize the effect of multiple controllable parameters and their interactions. Easily separated, longer and finer fibers were formed at lower SME 23–27 kJ·kg^{-1}, higher Texit 50–54 °C and shorter RT 55–60 s, conditions that were reached at Th of 90 °C, SP of 150 rpm and full-L of the extruder. Microstructure of the parallel protein fibers separated by fat particles was clearly observed.
Conclusions: The relation between controllable extrusion parameters, characteristics of the extrusion process and properties of the curd provided new insights that can be further explored to produce structured cheese products with customized properties.

Oral

Heat transfer coefficients and temperature distribution in conventional and microwave-assisted pasteurization of mango pulp

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Mango is the second most produced tropical fruit and the fourth most exported worldwide. Emerging electric and dielectric technologies, such as continuous-flow microwave heating, offer advantages over conventional processing. The objectives of this work were to study, model and simulate heat transfer and temperature history in the continuous flow pasteurization of mango pulp. For that, a Lab25-UHT/HTST EMVH pasteurization unit (MicroThermics, USA) was used, which consist of two countercurrent helical coil heat exchangers (Heater 1 and Cooler, with water as utility), a microwave heater (Heater 2) and a holding tube. Palmer mango (Mangifera indica L.) pulp was extracted and processed by conventional and microwave heating methods for process temperatures of 70, 75, 80 and 90 °C and residence times of 30, 20, 10 and 5 s. The experimental overall heat transfer coefficient (U) was determined from the heat loads of the product. Four semi-empirical models for U were tested, which considers the convective and conductive thermal resistances and use up to seven parameters. The correlations were adjusted minimizing the mean squared error for prediction of U. For Heater 1, correlation with six parameters provided a good fit, while for Cooler only three parameters were necessary, and for the holding tube, an average value was considered for the heat losses. The best adjusted correlations were used to predict the temperature history T(t) considering a mathematical model of unidimensional flow. Simulations provided the temperature history along the process. The difference between predicted and experimental temperatures were under 1.3, 1.7, 4.3 and 3.7 °C for Heater 1, Heater 2, holding tube and Cooler, respectively. The temperature history for conventional heating indicates that the product stays at the process temperature way longer than needed, which may suggest over-processing. Microwave heating occurred in less than 5 s at the lowest flow rate (0.2 L/min), while conventional heating took 20 s at the highest flow rate (1.2 L/min). Therefore, for all process conditions, microwave heating was faster than conventional. The proposed model can be used to evaluate the lethality of the process for both processing methods.
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Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Development and validation of models for heat treatment of concentrated skim milk in batch and continuous process

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Milk undergoes many chemical and physical changes during heat treatment that may lead to undesirable properties such as coagulation and gelation. This heat instability is often associated with milk proteins, such as the denaturation and aggregation of beta-lactoglobulin (ß-lg). The majority of kinetic studies to date have been conducted under isothermal batch conditions. Incorporating the heat transfer phenomena is important to transfer the kinetics from batch to continuous systems as tubular heat exchangers are commonly used in dairy processing.

Processing at higher milk concentrations improves sustainability of production through higher energy efficiency and lower transportation volumes. Higher concentrations increase reaction rates and also the viscosity of the product, affecting fluid flow and the resulting time-temperature distributions during processing. In this study, the kinetics of heat-induced ß-lg denaturation reaction in concentrated skim milk were coupled with models for heating and residence time distributions in tubular heat exchangers. The resulting model allows for an understanding of how processing conditions can be manipulated to optimize milk quality at an industrial scale. Model predictions are compared with experimental data collected from a pilot-scale UHT processing unit.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

CFD Study for Shell and Tube Heat Exchanger Design: Novel Baffle and Tube Arrangements

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For continuous thermal processing of liquid food products, heat exchangers hold a significant place in industry. Shell and tube heat exchangers are the most common ones in industrial applications, and various technical designs have been proposed to improve their thermal performances. Configuration and arrangement of the baffles and tubes were also demonstrated to have a profound impact on the performance of these heat exchangers.

In this study, novel baffle and tube arrangements were considered, and the effects of the segmental baffle (PS), novel baffles with three different bend angles (PR25, PR40 and PR60), and various sequences accompanied with tube arrangements (perforation, square, circular and pentagonal) were studied. CFD studies were carried out using Solidworks Flow Simulation software (Ver. 2018). The superheated steam of 450 K was used as a shell-side fluid and the milk at 277 K as a tube-side fluid. The temperature difference obtained across the tube side of the heat exchanger and total pressure drops across the shell side were determined for the effects of various arrangements.

To compare the temperature difference obtained across the tube side of the heat exchanger, 11.44 and 22.63% difference over the novel baffles with highest bended angle (PR60) were represented by segmental baffle (PS) and conventional (P0) shell and tube heat exchangers, respectively. In addition, PR was determined to lead to a lower pressure loss (35.1 and 0.27% lower compared to the PS and P0, respectively). Besides, P0 was found to have 2.27, 1.77 and 2.29 times higher than circular (D0), square (T0) and pentagonal arrangements (B0) in temperature difference per unit pressure loss, respectively.

A significant observation of this study was that shell and tube heat exchangers with baffles at different bending angles outperformed compared to the conventional segmental baffles. In addition, shell and tube heat exchangers containing baffles with the highest bending angle were also determined to have a higher thermal efficiency, and the perforation type showed the best performance for the thermal and hydraulic criteria for all arrangements.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Concentration of Liquid Food Extracts Based on Process-Controlled Gas Hydrate Formation

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CO2 gas hydrates can be observed in aqueous systems at elevated pressure and temperatures above 273 K. They offer prospect to increased energy efficiency and concentration at low thermal load for liquid food extracts, such as fruit juice, sugar cane juice or coffee. The aim of the current contribution was to study the formation of CO2 gas hydrates in a batch autoclave system for pure water and reconstituted soluble coffee in a theoretical and experimental approach.

CO2 gas hydrates were formed in a batch autoclave system with pure water and reconstituted soluble coffee at different concentrations. The influence of the coffee concentration was evaluated based on the induction time, i.e., the time required for the first gas hydrates to form. Moreover, different process conditions with varying initial concentration, pressure and temperature settings were tested, with focus on their influence on macroscopic hydrate structures.

Once stable hydrate conditions were reached after process initiation, instantaneous hydrate formation in both pure water and reconstituted coffee was highly reproducible, with a success rate of over 90 %. The coffee concentration was shown to influence the induction time for hydrate formation. In some cases, hydrate formation with induction times so close to zero were observed, that they could not be quantified.
Every process, when illustrated as a trajectory in a p-T-diagram, evolved in the hydrate stable region, for all chosen process conditions. Varying temperature and pressure levels resulted in different gas hydrate morphologies, ranging from highly dispersed gas hydrate crystals (characteristic length: 1 mm) in coffee slurry, to ordered and topologically simple, large-scale, continuous structures (characteristic length: 10 cm). Within latter structure, an anisotropic distribution of gas hydrates was observed.

CO2 gas hydrate formation can be triggered in pure water and reconstituted coffee solutions at different concentrations. Both the concentration and the chosen process conditions influence the morphologies of the formed hydrates. The formation of large-scale continuous structures with simple morphologies offers prospect to efficient separation of the solid gas hydrate phase from the remaining liquid, even at ambient conditions. Ultimately, the liquid concentrate can be obtained with minimized coffee loss at low energy input.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Unravelling food thermal reactivity by an original methodology to analyze and model reactions during baking of a model cake

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In baked foods, formulation and process steps lead to the generation of a multitude of compounds responsible for quality through the activation of thermal reactions. However, determining the link between composition, reactivity and quality determinants is not an easy task because of the interdependency of physical and chemical parameters and the complexity of real ingredients. Therefore, studying transformations in a food matrix under strictly controlled physical, structural and chemical conditions is of paramount help to verify the hypotheses formulated by many decades of results obtained in simple model systems (far from real foods) or in real products (with limited understanding on specific reaction pathways).

Using a model cake with a structure and manufacturing dynamics comparable to those of a real cake and containing only controlled amounts of defined precursors (glucose with/without leucine), two observable reaction patterns could be built and compared to experimental kinetic data measured on numerous markers (precursors, intermediates and products). Volatile markers were sampled from baking vapors by an on-line sampling device and quantified by TD-GC-MS while non?volatile markers were extracted from the cakes and quantified as follows: reducing sugars by UHPLC-CAD, free amino groups by titration, dicarbonyl intermediates by UHPLC?MS, furfural and 5-hydroxymethylfurfural by UHPLC-DAD. Temperatures (oven and in?cake) and water content were monitored during baking under controlled heat treatment conditions (3 temperature set?points and 2 convection levels).

The results showed that the impact of convection on the reactions was very limited compared to that of temperature and formulation. The caramelization and Maillard reaction pathways with glucose and leucine as precursors were clarified and consolidated. Formation of glyoxal and diacetyl from 1?deoxyosone could be neglected. Leucine acted on the Maillard reaction which overpowered the eneaminol-induced caramelization of glucose. The importance of isomerization of glucose to fructose was also highlighted. The kinetic evolution of furfural and 5?hydroxymethlfurfural was modeled in both the matrix and the vapors, paving the way for possible quantification of many volatile markers for kinetic modeling. These data constitute a complete and original database, which can be useful for the construction of stoichio?kinetic models and the quantification of the preponderance of specific reaction pathways.

Oral

Photon-induced reduction in barley malt processing time and quality improvement

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Barley (*Hordeum vulgare* L.) is the traditional grain for making malt because of its inherent and abundant content of and ability to synthesize critical hydrolytic enzymes needed in the downstream processes (fermentation, baking, and confectionary production). The malting process is done in three steps – steeping, germination, and kilning, of which germination is a major rate-limiting step. It takes more time to germinate than to steep or dry, and this is where most of the biochemical reactions that make barley malt what it is taking place. In order to increase return for the stakeholders in malting production, it is critical to find means to reduce the processing time, particularly the germination time, while maintaining or improving the malt's quality attributes. In this study, we proposed the application of modulated photon energy to increase abiotic stress during barley germination with light-emitting diode (LED) and pulsed ultra-violet (UV) sources. In dual photoperiod (12 h on – 12 h off), LED systems were used to supply photon energy between 75 to 150 PAR (µmol/m^2/s) for a period of 0 to 5 days of germination. The dried barley malt indicated that the treated samples showed a comparable amount of diastatic power (DP) (150 – 172 °L) and gamma-aminobutyric acid (GABA) (29 – 32 mg/100 g), a major bioactive compound between day 3 and 4 of germination with a range that surpasses what is desired for most malt application. A similar energy range was simulated for the pulsed UV light system, and we obtained similar results on the 3rd and 4th day of germination. However, the beta (*β*)-glucan level, a constituent of the cell that creates filtration problems when malt is used for brewing, had an exceptionally high level indicating minimal degradation during steeping and germination. Overall, this study showed that controlled application of photon energy could reduce malting time. Future work will focus on the application of other photon sources and exploration of means to modulate β-glucan levels in the final malt.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

The effect of lipase and glucose oxidase on the retrogradation of starch in frozen cooked rice

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We previously reported that adding lipase (Lip) or glucose oxidase (GO) to cooked rice reduced the retrogradation of starch in cooked rice during frozen storage. It has been hypothesized that an enzymatic reaction promotes the formation of the intermolecular S-S bonds of proteins in rice grains, thus inhibiting water absorption by starch and reducing its retrogradation. This study aimed to verify this hypothesis.

For this study, 150 g of rice, produced in Japan in 2018, was mixed with 200 U of Lip and/or 1.5 U of GO and 202.5 g water then heated in an electric rice cooker. The cooked rice sample was stored in a freezer or a refrigerator. The peak area at $2\theta = 17°$on the X-ray diffraction diagram of the rice sample defined the degree of starch retrogradation. The contents of free SH groups in the rice protein were measured using a modified Ellman method and also in rice samples to which catalase had been added before cooking.

The content of free SH groups in rice samples with added Lip or GO tended to decrease in 4-20 and 2.5-5 min from the start of cooking, respectively, indicating that S-S bonds had been formed during those periods. Adding catalase, which catalyzes the decomposition of hydrogen peroxide, significantly increased the content of free SH groups in the samples with added GO, suggesting that the hydrogen peroxide generated in the presence of GO had promoted the oxidation of the SH groups and the formation of S-S bonds. The S-S bonds of rice proteins in rice samples with added Lip started to be formed at the gelatinization temperature, which suppressed the breakdown of starch granules due to excessive water absorption and thus reduced starch retrogradation during freezing. The S-S bonds of rice proteins in the sample with added GO began to be formed before the starch began gelatinizing, thus inhibiting water absorption during the gelatinization process and reducing starch retrogradation during freezing. Overall, the stage at which S-S bonds were formed in the proteins in rice grains affected the degree of starch retrogradation during freezing.

Oral

Changes of carrot cell membrane and leakage of intracellular ion induced by low temperature blanching

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Low temperature blanching can improve the cell walls strength of vegetables by activating pectin methylesterase. Because cell membrane damage during this process modifies the environment in which the enzyme exists, the effect would be changed depending on the degree of the damage. In this study, we focused on the effects of low temperature blanching conditions on tissue conditions, including cell membranes.
Carrots were cut into discs having 20 mm diameter and 4 mm height. These samples were put into 200 mL deionized water for 40 min at 50 ?C and 60 ?C as low temperature blanching, respectively. Afterwards, cell membrane damage was evaluated by electrical impedance measurement and equivalent circuit analysis. Furthermore, the amounts of cations remaining in the tissues were quantified. The samples were homogenized with 1 %(w/v) hydrochloric acid and amounts of Ca^{2+}, Mg^{2+} and K^{+} were measured by using an IPC-AES. Besides, pectin methylesterase were extracted from raw carrot with 1 M NaCl. Then, the activity in 20 mL of 0.5% citrus pectin solution with Ca^{2+}, Mg^{2+} and K^{+} were evaluated by 0.01 M NaOH titration.
The equivalent circuit model was well fitted to the measured impedance values and the cell membrane capacitance was successfully determined. The capacitance value of the sample treated at 60 ?C was less than at 50 ?C. Thus, it was suggested that the treatment at 60 ?C accelerated the cell membrane damage. In addition, significant cation reductions (Mg^{2+}, K^{+}) were occurred at 60 ?C. These results showed that the degree of cell membrane damage differed with the treatment temperature and modified the ionic conditions in the tissue. Furthermore, significant increment of the pectin methylesterase activity due to the existence of Ca^{2+}, Mg^{2+} and K^{+} at each specific concentration was found. Hence, it was assumed that low temperature blanching enhanced the enzymatic reaction not only by providing activation temperature but also by promoting the intracellular cation leakage.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Adsorption study of molecules with surface-active properties on the interface of milk fat globules: application to high pressure homogenization process

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High pressure homogenization processes are often used in the dairy industry in order to achieve homogeneous and stable dispersion of the fat in the formulated milk product. These operations, consisting of splitting the milk fat globules into smaller units, lead to an area increase of the interface between lipidic and aqueous phases which is progressively covered by surface-active molecules and a significant reorganization of the fat globule interface. The fat globule size and interface can then modify the textural and sensory properties of the dairy products in which it is dispersed.

The general aim of this work is to better understand and model the structuring of the milk fat interface by the homogenization process. Modelling is combined with two complementary levels of experimentations. On the one hand, tensiometry experiments are carried out in order to simulate the adsorption of the various surfactants naturally present in milk (phospholipids, whey proteins, caseins) on a single fat droplet (anhydrous milk fat). On the other hand, high pressure homogenization experiments (HPH) are carried out on model milks of varying composition after which granulometry and interfacial charges are measured.

From the tensiometry experiments, through modelling by the Ward-Torday approach, the diffusion and adsorption characteristics (saturation surface excess, critical concentration at which half of the surface is covered by the surfactant, diffusivity) were determined assuming Langmuir model for adsorption isotherm. Then, using these parameters, a multi-component diffusion-adsorption model was developed to simulate the main phenomena occurring during HPH treatment. In a first approach, some simplification assumptions were made (e.g. fragmentation occurs very rapidly compared to diffusion, diffusion occurs trough a non-turbulent sub-layer)

This communication presents the general modeling approach, an example of parameter estimation from tensiometry measurements and an example of simulation of fragmentation/diffusion/adsorption in the HPH process. It illustrates not only the phenomena of individual adsorption of surface-active molecules but also competition and synergy phenomena during homogenization process.

This work initiates an approach to better understand the impact of homogenization processes and more broadly the interfacial phenomena and thus how to modulate the formulation and the process in order to obtain optimal properties.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Modelling of Molecular Distillation for Tryglyceride-Fatty Acid Separation

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Molecular distillation, one of physical separation of free fatty acids (FFA) from triglycerides has gained much attention in edible oil industry. Both experimental and simulation approaches were done using falling film molecular distillation for the separation. A binary mixture of oleic acid up to 10wt%, as FFA with refined soybean oil as triglycerides were used. Effects of temperature from 110 to 160°C and FFA concentration on molecular distillation process were investigated. Feeding rate was 0.30 kg/h and pressure was maintained at 0.1 Pa. Evaporator length and surface areas were 0.16 m and 0.018 m^2, respectively. FFA removal behavior was characterized from the mass analysis and chemical analysis of FFA. Higher temperature caused more removal of FFA. FFA removal ratio depended on temperature, but did not depend on FFA content. In order to characterize the molecular distillation process, mathematical model was introduced based on mass conservation and transport phenomena, and differential equation was obtained. If the FFA content is enough small, analytical solution of the differential equation was obtained as simple governing equation for molecular distillation. This simple governing equation had experimental parameters of temperature and FFA content, equipment parameters such as length of evaporator and diameter of evaporator, and process parameter of molecular distillation coefficient, h*. The coefficient, h* could be obtained by one set of experiment. After getting the value of h*, simulations under all other experimental conditions were carried out. Good agreement was obtained in the all the data between experiments and simulation. This means that proposed governing equation can be applied to separation of triglycerides and fatty acid mixture at any conditions of temperature and FFA content up to 10%, in which prediction and optimization can be done for scaling up and industrialization. The proposed model was developed for FFA removal from vegetable oil, but it could be also effective for other systems such as tocopherol recovery from vegetable oils, and squalene recovery from olive oil and so on.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Oral

Designing an Electrophoretic Separation System for Oleosomes and Proteins

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Oilseeds play a significant role in establishing more sustainable food production with their high oil and protein content, as both can be utilized as plant-based functional ingredients. Currently, an intensive oil extraction process is applied to extract oil, which degrades the quality of both oil and proteins. To take full advantage of oilseed compounds, a gentle process is needed that will sustain the quality of both oil and proteins. The present work aims to design an electrophoretic separation process that enables us to recover intact oleosomes and proteins from the seeds following a mild alkaline extraction. Rapeseed is used as a model oilseed. The electrophoretic separation is based on differences in the electrophoretic mobilities of the compounds. Rapeseed oleosomes and proteins exhibit significantly different electrophoretic mobility at pH ≥ 6, yet both are negatively charged at this pH range. The separation can be achieved by imposing a counter-current hydrodynamic flow at a rate that is between the electrophoresis rate of oleosomes and proteins. Thus, the compounds with higher mobility, oleosomes, are retained by the electric field and the compounds with lower mobility, proteins, go along with the flow. To theoretically prove the principle, the separation was modelled using the Nernst-Planck equation, and to demonstrate the principle, a PDMS-based microfluidic system was built that allows direct observation of the movement of oleosomes and proteins under a fluorescent microscope at varying electric field strengths and flow velocities. Both the modeling and the experimental studies indicated migration of oleosomes and proteins can be steered changing the electric field strength and the flow velocity. Certain combinations of the electric field strength and the flow velocity resulted in separation of oleosomes and proteins. A further increase either in the electric field strength or the flow velocity, however, hinders the separation, as both oleosomes and proteins move in the same direction. Overall, the conducted research revealed theoretically and experimentally the designed electrophoretic separation system is accomplishable, and it can be a novel path to separate oleosomes and proteins.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Impacts of the baking heating rate on the water mobility, starch microstructure and mechanical properties of degassed crumb during staling

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Keywords: Staling, Heating rate, Amylopectin retrogradation, Amylose crystallization, Proton water mobility, Firmness,

Introduction: Different parameters related to the baking process, such as the baking temperature, heating rate (HR), baking duration and temperature beyond the gelatinization temperature affect the texture and staling rate of bread.
Objective: The aim of this study was to assess the impact of the HR from 6 to 40 °C/min on bread crumb staling in terms of the 1H proton water mobility, starch microstructure, texture, soluble amylose (AM), amylopectin (AP) retrogradation and AM crystallization. In addition to the large HR range tested, there is a novel focus on the amount of AM complexes formed during baking as a function of the HR.
Methods: A degassed breadcrumb baked in a miniaturized baking system was used to ensure better time-temperature control during baking permitting to obtain a large range of HRs (6 °C/min, 20 °C/min and 40 °C/min). The properties of the crumb were evaluated to monitor different parameters related to the progression of staling, including the texture, AP retrogradation and AM crystallization. Water mobility was assessed by low field Proton nuclear magnetic resonance (1H NMR) , and environmental scanning electron microscopy was used to examine the extent of starch granule disruption.
Results: NMR data showed that the evolution of the proton T2 relaxation time decreased with increasing HR during staling. The amount of soluble AM, AP retrogradation degree, AM crystallization degree and crumb firmness tend to increase at higher HR. Microscopic observations demonstrated that most starch granules in crumbs treated at higher HR exhibited strong deformation and disruption.
Conclusion: These results confirmed that the increase in crumb firmness during staling with increasing HR was related to a higher level of starch disruption. This yielded a higher degree of separation between the AM and AP, which resulted in more pronounced water trapping in the starch crystals. The resulting dehydration of the matrix (gluten network, with AM gel surrounding of starch granules) yielded a loss in crumb softness, and crumb baked at higher HR tended to have a firmer texture and faster staling.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Changes in the quality of apple tissue subjected to different freezing rates during long-term frozen storage at different temperatures

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Frozen storage is an energy-intensive process. There have been attempts by the leading FMCG groups to reduce the energy consumption and carbon footprint of this process by looking at options like elevating the current used standard storage temperature i.e. -18°C (Morrison, 2022) to -12°C. In such an event, a reduction in energy consumption of 24% by elevating the temperature from -18°C to -12°C was achieved in a pilot trial of ice cream storage, with products still being sold and quality still maintained by reworking the microstructure and the matrix better suited to warmer temperatures. Such an outcome encourages exploring the higher storage temperature impact on other food matrices as it would benefit three axes i.e. energy/cost, environment, and operator.
This study was designed to test the impact of higher storage temperature on the quality attributes of apples during a prolonged storage period. For this, apples having different initial microstructures (from different freezing rates), were stored at -18 and -12°C and the quality was evaluated every 30 days during the 90 days. As expected, the initial freezing rate (static freezing (SF), rapid freezing (RF), and ultra-rapid freezing (URF) at 0.97, 8.27, and 28 cm h-1, respectively) significantly affected the quality attributes (i.e. firmness, drip loss, and microstructure) after freezing and during the storage period. URF best preserved the quality attributes of apple samples immediately after freezing, while RF better preserved the quality during the storage period of 90 days. During frozen storage, the greatest change in texture happened in the first 30 days, beyond which the difference in firmness was not significant. Similarly, drip loss increased gradually with the increase in storage time. Samples stored at a lower temperature (-18°C) were significantly firmer and had lower drip loss than those at a higher temperature (-12°C). However, the difference was not that huge. At the end of 90 days, the damage to apple microstructure could not be prevented even at -18°C; huge configuration changes in ice and cell morphology compared to day 0 were observed. This encourages similar studies focusing on different food matrices of various sizes to be conducted.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Slaughter weight and beef cut effect on the tenderness of Cachena meat

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Consumers consider three attributes when buying meat: appearance, colour and supposed tenderness. After purchase, while consuming, the most important attribute is tenderness. Consumers are willing to pay a higher price for beef that is guaranteed to be tender. Cachena is a cattle breed of the Portuguese genetic heritage, very interesting for the south Alentejo, a poor agricultural region of Portugal, due to the high rusticity of these animals. Cachena's meat is known by its excellent characteristics of texture and flavor. This study aims to evaluate the effect of slaughter weight and beef cut on Cachena's meat tenderness. Texture was evaluated by a compression double cycle test named texture profile analysis (TPA) and Warner-Bratzler shear force (WBSF) of the muscles Longissimus dorsi (LD) and Psoas major (GP) of two groups of animals of different weights. The light animal group consisted of 16 animals with live weights between 142-225 kg, and the heavy animal of 16 animals with live weights between 272-335 kg. Sensory attributes were assessed by a trained panel through a quantitative descriptive analysis of the LD muscle. Results were analysed with Statistica v.12 software using ANOVA and Tukey's HSD test ($P<0.05$). Meat tenderness was influenced by slaughter weight and meat cut. There were significant differences in meat tenderness between animal groups, light animals have more tender meat than heavy animals, according with TPA results (11.12 N±4.57 and 15.17 N±7.22, respectively). However, considering WBSF results, the LD showed higher shear forces compared to the GP muscle, which may be related to more connective tissue in light animals. Regarding meat cuts, LD meat (15.70 N±7.83) is less tender than GP meat (10.92 N±3.21), according to TPA results. These results were in accordance with those from WBSF, because it is necessary to apply greater shear force to LD than to GP meat.
Regarding the sensory analysis, the tasters consider that the heavy animals have tender meat, which is in line with the WBSF results. The sensorial evaluation is therefore better predicted by shear force results than by the firmness, as force required for compression, as is usually assumed.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

The effect of glazing on texture and sensory properties of Alentejano pig meat

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The Glazing process is usual in sea food preservation and remarkably slows the occurrence of rancid by oxidation, due to the weak solubility of oxygen in ice, decreasing the occurrence of protein denaturation (Zoldos et al., 2011). Besides, water losses decrease, influencing texture and sensory characteristics.
The aim of this study is to assess the effect of glazing meat from “Alentejano” (a Portuguese breed) pigs on meat texture measured by Warner-Bratzler shear force (WBSF), and sensory evaluation. Commercial cuts, obtained from the latissimus dorsi muscle were submitted to a glazing process that consists in the application of a protective layer of ice, formed on the surface of a frozen food through the immersion in clean water. The meat, packaged in a plastic film, was maintained at -21 ºC, humidity of 100 %, until the samples are collected. Two conditions were compared, namely, glazed meat and control (meat that was not glazed), at two different times: 0 and 6 months. Texture analysis, namely WBSF, was performed according to the protocol of Caine et al., (2003), while sensory evaluation was carried out using a trained panel and a special room following the International standards (ISO 8586-1, 1993; ISO 8589, 2012). Attributes such as fibrousness, succulence, hardness, colour intensity and flavour were evaluated. An ANOVA was performed and statistically significant differences were evaluated through a Tukey HSD test ($p<0.05$). No significant differences between control and glazing were observed, according to WBSF values ($p=0.799$). Regarding sensory analysis, glazed meat showed higher colour intensity ($p=0.015$) and hardness ($p<0.01$), but lower succulence ($p<0.01$) and flavour intensity ($p<0.01$) values. It is possible to conclude that glazing has no evident advantages up to six months of preservation. However further studies are needed to understand if it can be more advantageous for longer storage periods.

This work was supported by ICAPP - Research in Alentejo Black Pork Meat, reference POCI-01-0247-FEDER-072109, co-financed by the European Regional Development Fund (FEDER) through Compete 2020 – Competitiveness and Internationalization Operational Program (POCI).

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effects of storage conditions on the retrogradation properties of Xiaozhan rice

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The retrogradation of rice during storage will seriously affect the taste and flavor of rice. In order to further improve the storage conditions of rice and reduce the quality decay caused by retrogradation properties, the changes of starch structure and physicochemical properties of Xiaozhan rice at different storage temperatures (0?, 4?, 10?, 15?, 25?) and storage times (15d, 30d, 45d, 60d, 75d) were studied in this paper. Starch, amylose and amylopectin were extracted from Xiaozhan rice at different storage times and temperatures, and the color reaction was observed, and the retrogradation rate, chain length distribution, molecular weight, infrared spectroscopy (IR) and X-ray diffraction pattern were measured and analyzed. The correlation between storage conditions and those physicochemical properties was investigated. The results shown that there was a positive correlation between temperature and starch retrogradation rate after 75 days of storage (R2=0.64, r=0.806), the starch retrogradation rate was the lowest at 0?, and the fluctuation was the least during the whole storage period. Combined with IR and X-ray diffraction, it was found that low temperature was beneficial to maintain water molecular content and relative crystallinity of Xiaozhan rice starch, which could maintain good edible taste and nutritional quality of rice. The results of this study shown that there was a correlation between storage conditions and physicochemical properties of rice, which would provide data and theoretical basis for the optimal selection of Xiaozhan rice storage environmental parameters.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Sensors to follow in real time the tomato and apple quality attributes during processing in puree

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Keywords: fruits and vegetables, thermo-mechanical processing, automated systems, volatile organic compounds, GC-MS, visible and NIR spectroscopy,

The interest of real-time measurements for F&V processing:

Fruit and Vegetables (F&V) are reactive with **variable** properties and compositions depending on species and varieties, maturity stages, processing conditions... Developing a smart processing device able to **live-diagnose** the change during **processing** is a challenging objective for controlling quality and optimizing processes.

Our project aims at **customizing** a cooking and grinding pilot for R&D. It allows thermo-mechanical processes equipped with a double-wall tank heated by steam, in which pressure/vacuum and product temperature are continuously **monitored** and **controlled** (®RoboQbo, Parma, Italy). Our first achievement was to integrate both, near infrared (NIR) and visible **spectroscopy** as optical sensors and a device for **trapping** volatile organic compound (**VOC**) in the cooking vapor.

Visible and near-infrared spectroscopic sensors:

Commercial NIR and visible spectrometers were connected to the pilot through an optical fiber, in order to register the product light **adsorption** during processing. As F&V adsorption properties vary according to their composition (water/sugar content, color), the spectral properties were studied in relationship with the **modification of composition** and texture of the matrices during processing in order to test and ultimately validate sensors for later use to **optimize** processing conditions.

VOC sampling and calibration for diagnostics:

A cooling and drying device was designed for sampling aliquots of cooking vapors through Tenax ® VOC traps during processing. This device was associated with another “static” device allowing calibration and quantification of VOC content by **gaz-chromatography mass-spectrometry**. When used “in tandem”, we were able to monitor the vapor composition during cooking of F&V. In order to quantitatively assess changes, **automated** condensation-injection systems are under development.

The “static” device is already automated allowing for a timely valve-controlled nitrogen flux pushing headspace’s VOCs through a Tenax® trap.

Further development of this pilot will facilitate the integration of the signals and composition for establishing **models to predict changes throughout processing.**

Poster

Air classification of hulled and dehulled peas and faba beans- effect on carbohydrate compositions

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Keywords: preprocessing, fractionation, carbohydrates,

An increased demand of plant proteins has initiated the utilization and processing of pulses. To produce protein enriched ingredients, the main strategies are either a procedure comprising protein extraction and recovery by precipitation (protein isolates) or a water-free or mechanical fractionation (protein concentrates). The latter route includes an initial dehulling and a dry fractionation process for peas (P) and beans (B). In this the ground dehulled (D) materials (DP and DB) are pneumatically conveyed in air classifier which separates into a so-called fine fraction (FF) enriched in protein and a coarse fraction (CF) material enriched with starch granules. For peas and faba beans the removed hull had a high content of total Non-Starch Polysaccharides (tNSP); 42 and 57%, and a lower content of oligosaccharides; 8 and 3%, respectively. The dehulled materials acting as starting materials for the air classification had a similar lower tNSP, e.g., 7,6 and 7,0%, respectively, and a higher content of oligosaccharides, e.g., 14,9 and 10,7%, respectively.
Analysis of the major target fractions, e.g., the protein concentrates from peas and beans, showed that although they were enriched in protein; 46 and 61% for of peas (DP-FF) and beans (DB-FF), the protein concentrates still contained NSP and starch. A large part of the insoluble non-starch polysaccharides (NSP) was removed by dehulling and mostly assigned to cellulose. Dehulled faba beans and peas contained similar amount of total and soluble NSP, of which the latter were assigned to pectin and arabinogalactan. Dehulled materials have a relative increase of soluble NSP. As for tNSP the content of oligosaccharides (% DM) were always highest in the protein fractions, including the fine fractions produced from hulled kernels. The common non digestible raffinose series of oligosaccharides (raffinose, stachyose and verbascose) are abundant in protein concentrates from the two pulses, independent of an initial dehulling.
Although the dehulling step does not have a large impact on the nutritional most relevant constituents of the target protein concentrate, air classification without a prior dehulling will has an impact on sensory attributes as well as introduce some technical problems when operated continuously at large scale.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Phase transitions during storage of infant milk formula powders produced under varying wet-mix processing conditions

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Keywords: glass transition, pasteurization, crystallization, spray drying, powder,

Infant milk formulas (IMFs) are commonly presented in spray-dried form due to their long shelf life and reduced transport and storage costs. IMFs have high lactose content and are susceptible to glass transition during drying and storage. Powders with low glass transition temperatures (Tg) are prone to stickiness, caking, and crystallization, negatively impacting the quality and stability of the product. Effects of composition and spray drying conditions on Tg have been reported, but less attention has been paid to the effects of pre-spray drying wet-mix processing conditions. The aim of this work was to evaluate the impacts of pasteurization temperature and total solids (TS) of the wet-mix on the phase transitions of IMF powders during storage. Four IMF powders (50%-75°C, 50%-100°C, 60%-75°C, 60%-100°C) were produced at pilot scale by dispersion of the ingredients (lactose, whey protein isolate, skimmed milk powder, sunflower oil, galacto- and fructo-oligosaccharides) in deionized water (T=65°C, pH=6.8), to obtain wet-mixes with 50 or 60% TS. The wet mixes were subsequently pasteurized at 75 or 100°C×18s, homogenized (P1st stage=13MPa, P2nd stage= 3MPa) and spray dried (Tinlet air=180°C, Toutlet air=85°C). Each formula was stored under “open package” (HR=58%, T=25°C) and “closed package” (multilayer sealed bag, T=25°C) conditions, for 4 and 12 weeks, respectively. IMFs stored in “closed package” were amorphous for 12 weeks, as indicated by DSC and XRD. In formulas stored under “open package” conditions, lactose fully crystallized between weeks 1 and 2. IMFs produced from wet-mixes with 60% TS presented broken particles, as shown by SEM, which accelerated the water sorption. As aw increased faster in 60%-75°C and 60%-100°C than in 50% samples, glass transition and crystallization occurred earlier. In conclusion, TS of the wet-mix affected the stability of the IMFs powders. Formulas stored under “closed package” conditions were stable for 12 weeks, as Tg was above the storage temperature (Ts=25°C). Under “open package” storage conditions, the water adsorption induced Tg reduction and lactose crystallization by week 2. Phase transitions occurred earlier in IMFs produced from wet-mixes with 60% TS, due to the morphology of the powder particles which accelerated the water sorption, reducing Tg below Ts.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

A comprehensive two-scale model for predicting the oxidability of fatty ester mixtures

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Keywords: oil thermo-oxidation, predictive modeling, fatty acid methyl esters, autoxidation, co-oxidation, radical-chain reactions,

The intricate mechanisms of oil thermo-oxidation and their accurate prediction have long been hampered by the combinatory nature of propagation and termination reactions involving randomly generated radicals. To unravel this complexity, we suggest a two-scale mechanistic description that connects the chemical functions (scale 1) with the molecular carriers of these functions (scale 2). Our method underscores the importance of accounting for cross-reactions between radicals in order to fully comprehend the reactivities in blends. We rigorously tested and validated the proposed two-scale scheme on binary and ternary mixtures of fatty acid methyl esters (FAMEs), yielding three key insights: (1) The abstraction of labile protons hinges on the carrier, defying the conventional focus on hydroperoxyl radical types. (2) Termination reactions between radicals adhere to the geometric mean law, exhibiting symmetric collision ratios. (3) The decomposition of hydroperoxides emerges as a monomolecular process above 80°C, challenging the established combinatorial paradigm. Applicable across a wide temperature range (80°C to 200°C), our findings unlock the production of blends with controlled thermo-oxidation stability, optimizing the use of edible oils across applications: food science, biofuels, and lubricants.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Ability of acid-induced gels to drain - Understanding of mechanisms and influencing factors by NMR methods

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Acidified milk products like yoghurt are important food products but there are relatively few reports on the mechanisms involved in gel draining and the effects of processing variables such as heat treatment, gelation temperature and milk composition on the important physical properties of acid-induced gels and their draining (whey separation) capacities. There are few proven measurement methods to characterize draining behaviour and kinetics of acid-induced gels, or to prevent draining difficulties. Most studies characterize the spontaneous exudation of gels or its syneresis, but this does not allow to know the behaviour of the curd during a mechanical draining. From a production perspective, the management of acid gel draining is more a matter of field experience and empirical practice than of a systematic technological approach, and when delays in draining occur, curative actions are applied after the fact. Moreover, poor draining can lead to large variations in "quality" of finished products, with consequences for consumer satisfaction. Here, we present time-domain Nuclear Magnetic Resonance (NMR) at low field and Magnetic Resonance imaging as innovative methods in the field to monitor and quantify in real time the whey draining. Different gels with various milk composition, heat treatment, gelation temperature have been studied and compared. Such results aim at providing companies with levers to control acid-induced gel kinetics and exudation phenomena by understanding the molecular mechanisms of draining with the ultimate aim of developing and making available to companies operational tools for prediction and control.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Contribution of NMR methods to characterize starch, gluten and water in cereal products

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Time-domain Nuclear Magnetic Resonance (NMR) at low field and Magnetic Resonance imaging are potential techniques for monitoring the behavior of flour constituents (starch and gluten) as well as the migration and distribution of water during the processing or storage of cereal products. The aim of the poster will be to emphasize the potentials of NMR techniques for the quantitative characterization of water transfers in model dough systems on different length scales. Most dough processing methods involve heating or cooling in the presence of moisture. Examples will be chosen to emphasize the performance of NMR for analyzing the changes that occur at microscopic and macroscopic scales, to deepen the knowledge of the structure-function relationship between starch and water, gluten and water, each playing a particular role in the mechanical properties of dough affecting its nutritional, physical, and sensorial properties.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Optimization of drying step for enzyme application: a heat sensitive ingredient

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Drying process can be used to stabilize heat sensitive ingredients like enzymes, probiotics bacteria… For these applications, freeze drying is often preferred. However, with more and more carbon footprint interest, drying alternatives must be developed or the formulation has to be optimized. This study proposes to answer these challenges by introducing other drying technologies and / or optimize the protective matrices formulation. To conduct this study, β-galactosidase from Aspergillus oryzae was chosen. This enzyme degrades the lactose, and represents the best treatment for lactose intolerant people in food and pharmaceutical industries. This molecule was microencapsulated in different stabilizing matrices: maltodextrin, trehalose and skim milk. Two other drying technologies: conventional spray drying and electrostatic spray drying were investigated and showed low energy consumption compared to freeze drying.
Matrices and drying processes effects on β-galactosidase activity were studied regarding lactose degradation. The reconstitution ability of all microparticles was also studied during 12-months storage at ambient temperature. A carbon footprint analysis was also conducted using a life cycle assessment.
The results show that the activity was mainly influenced by drying technology with lower stability for conventional spray drying. The enzyme activity was very efficiently preserved for 12 months in all matrices except for trehalose with conventional spray drying and skim milk with freeze drying. Nevertheless, the reconstitution ability of all microparticles was affected by both drying processes and matrices. This work allowed to define the best combination of drying process and matrix for powders preservation, considering β-galactosidase properties and evaluating the capacity to response for reducing the carbon footprint.
Keywords: β-galactosidase, electrostatic spray drying, spray drying, freeze drying, carbon foot print, reconstitution ability, storage stability.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Physicochemical, structural, microbiological and reconstitution properties of spray-dried kefir during storage

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Objective:
The aim of the present work was to evaluate the effect of storage time on the physicochemical, structural, microbiological and reconstitution properties of spray-dried kefir.

Method:
Kefir samples were prepared using homogenized and pasteurized semi-skimmed milk and commercial starter cultures (XPL-30, LAF-4, CHR HANSEN, Denmark). Following fermentation (30C until pH 4.4), a probiotic culture (BB-12, CHR HANSEN) was added to kefir and ten different sample formulations were prepared, one control without carrier addition, 3 samples with trehalose (1, 2, 4%w/w), 3 with fructooligosaccharides-FOS (2, 3, 6%w/w) and 3 with whey proteins (2, 5, 10%w/w). The samples were subsequently spray-dried at reduced process temperatures (inlet 140C, outlet 80C). The powdered kefir samples were stored at ambient temperature for 6 months during which period their properties were monitored.
Moisture content, color parameters, particle size distribution via laser diffraction, particle porous structure by confocal laser microscopy, as well as bulk density, tapped density, flowability, cohesiveness, water solubility index and insoluble matter content of powder samples were determined. Color parameters, pH, particle size distribution, morphology and microbiological viability of lactococci, lactobacilli, yeasts and probiotics were also evaluated at the reconstituted samples.

Results:
Carrier addition affected the reconstitution properties of the samples during storage when compared to control. Moisture content and structure of the samples was not altered during storage. The pH values of reconstituted samples were increased, compared to unprocessed samples for all treatments, but they did not exhibit further changes during storage. The color parameters of the powder samples during storage, was affected by the addition of carriers. Carriers also improved kefir microflora survival as it concerns lactococci and lactobacilli. Trehalose affected microflora survival the most. Yeasts did not survived after drying, nor did probiotics that exhibited very low viability.

Conclusion:
Carriers’ addition affected kefir powders properties during storage. Survival of lactococci and lactobacilli during storage improved the most in the presence of trehalose.

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers” (Project Number: 0075).

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effect of fermentation conditions and thermal treatment on the formation of kefiran and the rheological behavior kefir

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Objective:
The aim of the present work was to investigate the effect of inoculum, pH at the end of fermentation and thermal treatment post fermentation on the production of kefiran and the rheological properties of kefir.
Methods:
Bovine full fat milk and traditional kefir grains were used for kefir preparation. The milk was heat-treated, at 90C for 5min, cooled down at 30C and inoculated with different kefir grains concentrations ranging from 3 to 30%. Subsequently, fermentation was allowed at 25C until pH 4.4 or 5.5, and the resulting samples were transferred at 4C with or without the grains used for the fermentation. Kefir samples strained immediately after fermentation were placed for 24 h at 4C and then further analyzed for their kefiran content and rheological behavior. Kefir samples together with the kefir grains used in the fermentation were stored at 4C for 3, 7 and 15 days. At the end of the storage time the grains were strained and the resulting kefir samples were further analyzed. Moreover, inoculated heat-treated milk samples with different concentrations of kefir grains were stored at 4C, without fermentation, for 15 and 30 days before grain removal and analysis of the sample properties as mentioned above. The exopolysaccharide kefiran was isolated to high purity using trichloroacetic acid for protein removal and three successive ethanol precipitation steps. The apparent viscosity and viscoelastic properties of the samples (dynamic analysis and creep test) were evaluated using a DMA rheometer, Bohlin C-VOR 150.
Results:
Kefir grain concentration affected kefiran production irrespective of the final fermentation pH, or the time allowed to ferment at the ambient temperature of 25C. Increasing kefir grain concentrations favored kefiran production and improved the rheological properties, apparent viscosity and viscoelasticity. Intensive low-temperature thermal treatment conditions, such as long term storage in the presence of kefir grains also resulted in increasing kefiran concentrations and favored the rheological properties of kefir samples. Fermentation and final pH values affected the above mentioned properties to a lesser extent.
Conclusions:
Proper selection of fermentation conditions and thermal treatment of kefir can increase kefiran production and reinforce viscoelasticity of its protein matrix.

Poster

Edible kefiran films with probiotics - structure, physical properties and probiotic viability during storage as affected by cryo-treatment, kefiran concentration and milk protein addition

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Objective:
The present work evaluated the effect of cryo-treatment, kefiran concentration and milk proteins, sodium caseinates and whey protein concentrates, on the structure, physical properties and probiotic viability during storage of kefiran films.
Methods:
Kefiran was isolated from kefir grains and films, with or without cryo-treatment, were produced either with no other additives, at kefiran concentrations ranging from 1 to 3% (w/w), or with the concomitant addition of sodium caseinates and whey protein concentrates at 2%(w/w) concentration. For film preparation, the polysaccharide was dissolved in hot water, at 80oC, followed by the addition of milk proteins, when required, and heat treatment at 80oC for 30min. The probiotic culture (BB-12) was subsequently added at 30°C, and the film-forming solutions were subsequently transferred to petri dishes and subjected to cryo-treatment by slow freezing at -18°C for 24h, followed by defrosting at 4°C for 24h. Post cryo-treatment, the films were dried to constant weight in a lamina air flow oven at 40°C and stored at 25°C before further analysis. Films without cryo-treatment were also prepared. The physical properties of the films, thickness and moisture content, the probiotic culture viability and the film structure were monitored.

Results:
Cryo-treatment increased film thickness, but did not affect moisture content. Protein addition did not affect the films' physical properties but improved probiotics viability during storage of films subjected to cryo-treatment. Increasing kefiran concentration resulted in increasing probiotics viability as did cryo treatment. Kefiran films without cryo-treatment appear too rough when compared to films with cryo-treatment. The presence of probiotics made the structure of cryo-treated films appear smoother.

Conclusions:
Cryo-treatment and kefiran concentration affects films structure and improve probiotics viability. Milk proteins improve probiotic viability during storage.

This research is co-financed by Greece and European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021), implemented by the State Scholarships Foundation (IKY).

Poster

Effect of kefiran and milk proteins, sodium caseinates and whey protein concentrates, on the rheological properties and structure of cryogels

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Objective:
The present work investigates the effect of kefiran concentration and milk proteins on the viscoelastic properties and structure of kefiran cryogels.

Methods:
Kefiran was isolated from kefir grains and cryogels were produced either with no other additives, at kefiran concentrations ranging from 0.5 to 4%(w/w), or with constant kefiran concentration, at 3%(w/w) and the concomitant addition of sodium caseinates and whey protein concentrates at concentrations ranging between 1 to 4%(w/w). For cryogel preparation, the polysaccharide was dissolved in hot water, at 80°C, followed by the addition of milk proteins, when required, and heat treatment at 85°C for 15min. Samples with whey protein concentrates were also prepared without heat treatment. Subsequently, the cryogel formulations were cast in aluminum molds with serrated surface, adapted to the system of the rheometer used, and frozen at -18°C for 24h. Post-freezing, in order to induce cryogel formation, the samples were refrigerated at 4°C for 24h, prior to their rheological evaluation with dynamic analysis and creep-recovery tests at ambient temperature using a DMA rheometer, Bohlin C-VOR 150. The morphology of the cryogels was also examined using a Confocal Laser Scanning Microscope.

Results:
Increasing kefiran concentrations, addition of sodium caseinates and heat-treated whey protein concentrates resulted in increasing the viscoelasticity of the cryogel matrices. Kefiran cryogels display the characteristic cryogel macroporous structure. Low concentrations form more pores, while at higher concentrations the polysaccharide mesh is denser. The presence of casein salts in the system, effected cryogels with a granular texture, while heat treatment only affected the structure of the cryogels with serum protein concentrates, which appeared more open and with large pores in the case of non-denatured proteins.

Conclusions:
Kefiran concentration effects the formation of cryogels with varying density and elasticity matrices. The presence of milk proteins into the system of kefiran cryogels can substantially affect their structure and rheological behavior.

This research was co-financed by Greece and European Union (European Social Fund- ESF) through the Operational Programm «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021), implemented by the State Scholarships Foundation (IKY).

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Evaluation of potential multiscale mechanism of ultrasound-assisted mass transfer in porous medium: experiment and modeling on this intensified process

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Enhancement effect of ultrasound on mass transfer has been widely demonstrated and applied to extraction of bioactive compounds from natural plants, and this phenomenon was commonly attributed to cavitation damage presently. The purpose of this study is to propose a multiscale mechanism to supplement the theory of ultrasound-assisted extraction. Green coffee beans (GCB) were chosen as the experimental material to investigate the interactions of ultrasound and micropores on extraction as its internal structure would burst under overheating. First, the influences of ultrasound power, particle size and extraction time on total phenolics yield of GCB were studied by single factor experiment and response surface method. Afterwards, the property changes of roasted coffee beans (RCB) were comprehensively compared including pore morphology and phytochemicals contents (caffeine, trigonelline, chlorogenic acid and caffeic acid). Then the extraction yields (expressed as the percentage of total content) of GCB, RCB-120? and RCB-180? were measured along with 30 min. The differences of extraction rate and mass transfer rate between each group were compared by coefficients of empirical kinetic equations. Besides, the effects of porous characteristic on extraction at different particle sizes and ultrasound power were also determined. From the point of view of extraction yield, these results indicated that the mass transfer rate of RCB was significantly higher than that of GCB and this phenomenon became more prominent with ultrasound-assisted, which means not only the sonoporation but also the synergistic effect between ultrasound and porous medium could facilitate the mass transfer during extraction. At last, the multiphysics simulation was applied to modeling the distributions of sound pressure and flow field within the macro extraction system at different ultrasound conditions. Based on these, the dilute solution diffusion of mediums with different porosity could be also visualized to reveal and validate the multiscale mechanism of ultrasound-assisted mass transfer in porous medium. Overall, this work proposed a potential explanation of ultrasound-assisted extraction, and this finding could not only supplement the deep theory but also inspire other processings which rely on mass transfer. Notably, the confined cavitation and slippage flow on gas-liquid-solid interfaces at microscale induced by ultrasound still need further investigation.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Static agglomeration of food powder mixtures: influence of addition of an "inert" ingredient

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In the food industry, the term sintering usually refers to static agglomeration resulting from the bridge formation that occurs between neighbouring particles when an amorphous powder is exposed to temperatures above its glass transition temperature (Tg). Addition of an "inert" (i.e. a non-sintering) ingredient to the amorphous powder can have a major influence on the physical properties of the sintered product.
In this study, a sintering ingredient was mixed with an inert one using dry mixing, and the mixture was subjected to different temperature (T) and relative humidity (RH), above the Tg of the sintering ingredient. Different concentrations and particle size distributions of the inert ingredient were tested. It is shown that the particle size of the inert ingredient can have a significant effect on the physical properties of the final product. It is also demonstrated that a threshold concentration of the inert ingredient exists above which the sintering degree is not significant (within the range of conditions studied here). Finally, this study explores the differences between a purely thermal sintering process and a moisture-induced one, at the same T-Tg.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Low and high moisture extrusion of less refined ingredients – impact of processing conditions on texturization of defatted soy flour

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High and low moisture extrusion (HME, LME) can be applied to create meat-like structures in protein rich materials. The structure of final products differs: LME forms expanded, granulate-shaped products, HME imparts non-expanded, compact structures.

Besides the process conditions and the moisture content, also the raw material type has a major impact on quality and environmental impact of final products. With this regard, the use of less purified raw materials is considered to be more sustainable. Highly purified protein isolates are often mixed with starch and fiber to improve physical and sensorial characteristics of extrudates. However, defatted soy flour already contains higher amounts of different ingredients, beside the native protein. Hence, it can be assumed that this composition renders redundant any addition of other highly purified fractions.

The aim of this study was to investigate the influence of extrusion conditions (temperature and water feed rate) on physical quality of extrudates, produced by HME and LME from defatted soy flour instead of using soy protein isolates. Extrudates were produced with temperatures ranging between 145 and 165°C (HME) and 170 and 190°C (LME). Water feed rates ranged from 6.1 to 8.2 kg/h. Moreover, the ratio between water- and raw material feed rate ranged from 1.8 to 2.4 (for LME) and 3.4 to 4.5 (for HME).

HME products were characterized by analyzing firmness and springiness by texture profile analysis, cutting behavior and degree of texturization. LME products were analyzed by single compression testing of rehydrated, minced products.

Within products of LME and HME significant differences in textural parameters were found. Temperature had a positive impact on the degree of texturization during HME. Moreover, a higher water content during HME decreased as expected the firmness of final products. Higher temperatures during LME decreased the firmness of rehydrated, minced extrudates from 11.1 to 7.4 N. The results of the study showed, that less purified raw materials are also offering good processability for LME and HME. The formation of fibrous protein structures can be highly influenced by variation of extrusion conditions which allow to tailor the process taking into account the use of less refined ingredients.

Poster

STUDY AND OPTIMISATION OF FREEZE-DRYING CYCLES OF MODEL PROBIOTIC STRAIN OF LACTOBACILLUS CASEI TYPE

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A particular interest is dedicated on probiotic's industrial production in various sectors such as food industry for the transformation of animal or vegetal raw materials into functional food and, more recently, in pharmaceutical industries.

Freeze-drying is recognized as the drying method which gives the bests results in terms of survival and dried powder quality, regardless of the thermal stresses generated by the freezing step. But this method has the major inconvenient to have the more expensive operating costs due to severe operating conditions (very low temperature and pressure). Nevertheless, there exist a great number of types of strain and subspecies with completely different behaviors and properties. This is why the conservation and stabilization of these fragile micro-organisms is a very hard task, more often solved by trial and error runs with few experimental data in the literature. That's why the goal of the project was to study and to validate a global optimization methodology allowing to control the main quality factors like the highest bacteria survival ratios after a long storage period and the costs of the freeze-drying process.
Our rational scientific approach was based on the experimental study, step by step, of the freeze-drying process (freezing, sublimation, desorption) to understand the complex impact of the numerous factors impacting the survival ratios of a model probiotic strain of lactobacillus caseï.
We have chosen a formulation matrix with lactose basis with or without a polymer, namely the polyvinylpyrrolidone. Our preliminary important work consisted in establishing the state diagram of our formulation (freezing and glassy transition curves). These are the key thermo dynamical data necessary to adjust the optimal sublimation and desorption parameters.
Firstly, we studied the freezing step which was suggested by few authors as the most lethal step. This is why we firstly investigated some freezing protocols (cooling's rate, nucleation temperature, annealing treatment) leading to the highest survival ratios.
Next, with the preselected formulation we investigated the sublimation step. The heat transfer coefficient was characterized by an overall heat transfer coefficient determined with pure water. In our very soft operating conditions.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Chemical changes in papaya fruit during vacuum frying – a focus on sugars reactivities

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Vacuum frying was proved to be a viable alternative in order to produce stable fried foods with better nutritional and sensory properties. The high temperature, in combination with vacuum and oil immersion, causes physical and biochemical changes. Usually, these modifications are known and foreseeable. For instance, fat absorption and changes in food texture are expected. Likewise, there are chemical changes such as degradation of sugars, vitamins, proteins, and bioactive compounds, colored compounds increase, and starch gelatinization. However, previous published studies reported unusual biochemical changes, at the macro scale, particularly on sucrose increase during frying.

This communication aims to highlight sugars changes during vacuum frying of papaya fruit in order to understand these complex phenomena. A fractionated experimental design (3 temperatures and 3 vacuum levels) was realized using a vacuum frying pilot. Papaya was sliced, randomized, and fried for 6 kinetic points (0-20 min). Lipids, dry matter and sugars were quantified by gravimetry and HPLC respectively. A 4th order kinetic model was used to describe glucose and fructose decrease while sucrose production was modeled by a 1rst order kinetic.

During papaya frying, the high sucrose formation was correlated to simple sugar degradation, confirmed in molecular yield. At 25 kPa, the highest vacuum pressure, and 120 °C glucose and fructose content decreased from 46.4 and 45.8 % nonfat dry weight (DW-NF) to 15.6 and 14.0 % DW-NF after 15 min of frying process, respectively, while sucrose content increased from 0 to 37.0 % DW-NF. Statistical analysis of identified rate constants showed a strong correlation between simple sugar degradation rates and an increase of temperature while final content of sucrose was more correlated to an increase in the frying pressure. This observation suggests a different chemical pathway for the different sugar reactions.

Simple sugars condensation affected by pressure seems to be the most suitable explanation for sucrose production. Simple sugars contribute to this reaction but are also consumed for Maillard or caramelization reactions. Future works are needed to dissociate sugar degradation pathways between different condensation reactions leading to sucrose or caramelization or Maillard reaction products as a function of frying conditions monitoring

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

INVESTIGATION of EFFECT of THE CREAMED HONEY PRODUCTION PROCESS on THE 5-Hydroxymethylfurfural (HMF) CONTENT of HONEY

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The predominant compounds found in honey are carbohydrates, mainly composed of fructose and glucose. At the same time, honey is extremely rich in enzymes, amino acids, organic acids, vitamins, and phenolic substances. Honey is a supersaturated solution with more than 70% sugar and less than 20% water content. Crystallization of supersaturated solutions is expected from a physicochemical point of view. Most honey is supersaturated with glucose, which is less soluble than fructose; so at room temperature glucose is prone to crystallize in the monohydrate form. The water in honey binds carbohydrates with hydrogen bonds. It is understood from these situations that under certain conditions, the crystallization of honey (colloquially known as confectionery) is a very natural phenomenon. Controlled crystallization is a good alternative to prevent the undesired crystallization phenomenon in honey and the application of heat treatment to honey, is seen as a solution to improve this phenomenon. Creamed honey is a new product formed as a result of controlled crystallization made to improve the sensory and physical properties of honey, such as giving natural honey a spreadable feature, with crystals in very small sizes that cannot be perceived by the palate. In other words, honey is crystallized to make it spread like butter and prevent it from dripping. As a result of various processes (such as temperature) applied to honey, the amount of undesired 5-Hydroxymethylfurfural (HMF) may increase. In this study, creamed honey was produced from filtered honey and the effect of this creamed honey production process on the HMF content of honey was investigated by the High Performance Liquid Chromatography (HPLC) method. As a result of this study, it was concluded that the creamed honey production process did not have a significant effect on the HMF content of honey ($p>0.05$).

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Increasing the glass transition temperature by centrifugation to produce Clean Label tomato powder by spray drying

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Producing fruit powder such as tomato by spray drying is a challenge because of their high sugar composition. Drying of these types of products is subject to sticking and agglomeration of the powder during drying, which leads to a considerable drop in drying yield. Bhesh R. et al. (1997) stated that in order to avoid wall sticking and caking phenomena, the drying exit temperature should be lowered to 10-20°C below the glass transition temperature (Tg) of the product. However, it is not obvious to guarantee a product temperature at the end of the process, or during storage, lower than its Tg. This problem can be partly solved by raising product Tg by adding soluble dry matter. Maltodextrin is the most commonly used bulking agent to increase Tg of the products and avoid these phenomena during drying. However, the use of these additives has disadvantages such as bad effects on consumer health and reduction of bioactive nutrients concentration in the product. The objective of this study is to increase the Tg of the product, which is around 25°C, to a value close to 50°C at the end of the drying process in order to improve the drying yield and to obtain a tomato powder free of maltodextrin. Reducing directly the sugar content of the tomato juice before drying is a good alternative to increase the Tg of the product and avoid the use of these ingredients. Centrifugation at an acceleration of up to 13,000 g at a maximum duration of 15 min significantly reduces the sugar content of tomato juice. The increase in Tg with reduced sugar content is investigated in this work. These results are correlated to the behaviour of the powders submitted to different spray drying conditions. The aim is to produce tomato powder of high quality and allowing the consumer to take advantage of the molecules of interest of the tomato such as lycopene.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Application of physical and chemical pre-treatmens to improve quality and reduce energy consumption during freeze-drying of blueberries

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Freeze-drying is the best drying alternative to extend shelf-life while preserving bioactive properties of products. Interest in freeze-drying of blueberries is due to their high perishability, high content of bioactive compounds and relatively short harvest period.

Blueberries have high resistance to vapor transfer due to the structure of blueberry peel which is covered by a waxy layer. Because of this, blueberry freeze-drying is a slow and costly process. This high resistance also impacts quality of final product as internal vapor pressure variations during drying can cause structure collapse. The aim of this work was to evaluate the impact of different physical and chemical pre-treatments in blueberry freeze-drying rate and bioactive compounds content.

Blueberries (c.v. Emerald) were obtained from a local producer and processed within 24 h from harvest. Five different pre-treatments were applied: cut in halves; dipping in dichloromethane; dipping in methanol; dipping in sodium hydroxide and dipping in sodium carbonate. Control sample consisted of non-treated blueberries. Each pre-treatment was performed in triplicate.

The different blueberry samples were frozen (-20 ºC) and freeze-dried in a Virtis bench-top freeze dryer. Weigh loss throughout drying was measured every 24 h. Total freeze-drying time was considered when no weight change was observed in 24 h. Total monomeric anthocyanins and total phenolic compounds of control and pre-treated freeze-dried samples were determined. In order to evaluate structure damage after freeze-drying, rehydration test was carried on by dipping samples in water for 6 h and periodically weighting them.

Cut blueberries showed the lowest total freeze-drying time; 4 times less than control. Also, cut blueberries reached the lowest final total weight (14.8% of initial weight). Among the different chemical pre-treatments, sodium hydroxide showed the higher dehydration rate (half drying time compared with control). Dichloromethane samples showed the highest rehydration rate probably because the solvent acts on the superficial wax but does not penetrate, avoiding internal structural damage. No significant difference ($p<0.05$) of total phenolic or total monomeric anthocyanins content was observed among the different treated and non-treated samples.

Pre-treatments assayed in this study allowed to reduce freeze-drying time of blueberries while preserving bioactive compounds.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Sorption isotherms for apple pomace

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Apple is one of the world`s most consumed fruits. Its use in the production of juice, concentrated, pulp and cider generates large amounts of apple pomace (AP) as a byproduct, which has a potential for valorization. Apple pomace represents around 30% of the apple's weight and contains several valuable extractable compounds (pectin, phenolic compounds, etc.). In order to store AP for further processing, it must be dried to stop microbiological deterioration. Sorption isotherms are essential for an optimal design of the drying stage, assessing the stability of the dehydrated product and evaluating storage conditions. However, very little information regarding AP's sorption isotherms can be found in published literature. Moreover, the behavior of the sorption isotherms is heavily dependent on the particular characteristics of AP. The aim of this work is to experimentally obtain AP sorption isotherms in order to fit a model that can be used to predict AP behavior on the drying stage and in the storage conditions. Sorption isotherms were experimentally determined at three different temperatures (36, 50 and 60 ºC). Sorption isotherms at 50 and 60 ºC were obtained through the static gravimetric method and the sorption isotherm at 36 ºC was obtained through direct measurement of water activity in AP samples with different moistures. Guggenheim-Anderson-de Boer equation (GAB) was selected within classical mathematical models derived to predict sorption isotherms of moisture in food, as it is one of the most versatile for different types of products. GAB parameters were fitted using the data obtained at 36 and 60 ºC and the model was validated with the data obtained at 50 ºC. Correlation coefficient (r2) between the experimental and fitted data was 0.989, whereas the correlation coefficient for the validation was 0.996. The shape of the obtained sorption isotherm corresponds to a Type III curve, characteristic of food rich in soluble compounds. The obtained model allows predicting sorption isotherms for AP within a broad range of water activities (0.1 to 0.8) and temperatures of practical application (36 to 60 ºC).

Poster

Study of drying conditions of whole organic green banana in pulsed fluidized bed dryer.

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Green bananas are rich in resistant starch and other compounds recognized for their benefits to human health. According to data published by FAO, the world production of Musa in 2020 was 131.7 million tons. However, approximately one-fifth of production is wasted due to inappropriate transport and storage conditions. This research aimed to study the drying conditions of organic green banana (*Musa cavendischii*) with peel in a pulsed fluidized bed dryer (PFB) to obtain whole flour (WGBF) to enable better use of the fruit and preserve its nutritional characteristics. The green bananas at their first stage of maturation were previously crushed and treated with citric acid and then dried in a PFB with four sections. The influence of the inlet air temperature (T = 55 °C and 75 °C) and air pulsation frequency (PF = 300 rpm and 500 rpm) on the drying time was evaluated using a 2^2 factorial design with three replicates at the central point condition (T = 65 °C and PF = 400 rpm). The WGBF obtained from the particulate in each drying condition was evaluated for resistant starch content (36 to 43 g/100 g, d.b.), total starch content (70 to 78 g/100 g, d.b.), moisture content (3.3 to 8.1 g/100 g, w.b.), water activity (0.105 to 0.299), pH (4.25 to 4.36), and instrumental color (L^* = 80.6 to 83.6, a^* = 1.31 to 2.93 , b^* = 13.20 to 14.66). The drying time was only influenced by the T ($p<0.05$). The time to reach a reference moisture content of 10 g/100 g (w.b.) ranged from 53 min (75 °C and 500 rpm) to 130 min (55 °C and 300 rpm). The WGBF scanning electron microscopy images identified starch granules with rounded and elongated shapes with regular contours in the conditions studied. Drying unpeeled green bananas in PFB proved feasible, and the drying conditions studied preserved the high level of resistant starch (above 35 g/100 g, d.b.).

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Experimental Setup for Measuring Bread Physical and Chemical Properties During Baking

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Bread baking is a complex process subjected to chemical (e.g., Maillard reactions) and physical transformations (e.g., water loss and volume expansion). Those chemical reaction products give desirable color and flavor to food. However, they can generate contaminants such as 5-(Hydroxymethyl)-2-furfural (HMF), harming human health. This study built a finely controlled cavity to measure physical changes in bread baking and correlate process variables, bread physical properties, and HMF formation throughout the cooking process. The temporal evolution of temperature, humidity, mass loss, volume, porosity, core structure, color change, and HMF content was evaluated. The proposed experimental system presented longitudinal symmetry, ensuring greater control of the alterations suffered by bread. The bread lost 11, 15, and 17% moisture for baking at 180, 200, and 220 °C, respectively. Moisture loss occurred near the crust, while the central region increased up to 4.2%. Volumetric expansion in the baking was higher at lower temperatures, i.e., 27.6% at 180 °C, 23% at 200 °C, and 23.5% at 220 °C. The evolution of color presents a sigmoid profile for all parameters of the CIE L*a*b* space. A proposed model described the kinetics of the color development as a function of temperature with good values of R2 and RMSE. The HMF content is related to temperature from the power function with an R^2 of 0.9713. The formation of HMF does not occur until the bread crust reaches 150 °C. The HMF content is also related to color parameters, occurring when the crust of the bread reaches the maximum yellowing (b*) and luminosity values (L*) below 60. The proposed models described the formation of HMF according to the color parameters L* and b* with good R^2 (0.9713 and 0.9635, respectively), which allows the prediction of the HMF content from the color of the bread. The correlations obtained under controlled cooking conditions accurately predict the properties of the bread for each cooking configuration, allowing the design and optimization of the oven cavity.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Identification of solubilization kinetics of food powders using a sequential reconstitution device

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Food powders represent a large proportion of the total processed food in the world. There are several reasons for this, such as extended shelf-life, facilitated transport and usage conveniences, relatively high stability and the possibility of a high production rate. Preserving excellent functional properties strongly depend on powder processing parameters and storage conditions. For example, increase in water content during storage causes the powder adhesion through their surfaces leading to powder caking, loss of flowability, loss of solubility, which affect the quality of the final product. Thus, much attention has to be paid to the understanding of particulate food systems and how intrinsic and extrinsic factors can influence them. This involves control of surface and internal structures of the powder particles.
Studies carried out on reconstituted powders have highlighted the interdependence between the reconstitution time and the particle physicochemical properties, and particularly the particle surface composition. In the present work, a diafiltration method was employed to perform a sequential reconstitution and, to fractionate soluble components according to their presence at the surface/core of the particle. To this end, fractions were collected through a hydrophilic filter at defined times, and then analyzed (i.e., mineral, protein, lipid, sugar contents). The powders employed here present a singular reconstitution behavior according to their wetting time and their total reconstitution time. For example, a high protein dairy powder (80% casein / 20% whey proteins) presenting a long wetting step and a long reconstitution time was studied. It was evidenced that whey proteins were strongly enriched at the particle surface, whereas casein micelles were located at the core of the particles. This protocol also allows the identification of the rehydration kinetics for each rehydrated protein layer of the particle, revealing that two distinct forms of swelling occurred: (1) first a rapid swelling and elution of whey proteins present at the particle surface, and (2) then a swelling of casein micelles located below the whey proteins, associated with a slow elution of casein micelles from the particles being rehydrated.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

OPTIMIZATION OF SUGAR AND PALM OIL FREE NUT SPREADS

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Anhydrous sweet spreads are concentrated suspensions of poly-dispersed solid particles (sugar, cocoa, milk powder etc.) whose continuous phase is palm oil, probably the most widely used vegetable oil for the manufacturing of confectionary and sweet spreads. Despite its excellent technological properties, the use of palm oil is questioned because of issues related to human health and environmental impact, the last due to its intensive cultivation. Excessive consumption of palm oil is associated with cardiovascular risks (due to its saturated fatty acid content). Furthermore, palm oil can contain toxic compounds formed in the refining process, such as 3-monochloropropanediol and fatty acid glycidyl esters. Sucrose is commonly used in sweet spreads thanks to its important energy source; however, its excessive consumption is linked to short- and long-term pathologies (obesity, heart disease, etc.). Therefore, a growing interest in low-calorie sugar substitutes and in alternative plant-based palm oil replacers has been observed in recent years. Edible oleogels seem to be optimal replacers of palm oil in food products as they contain a large amount of edible oil entrapped in a three-dimensional network. Stevia as natural sweetener with a sweetening power 200-300 times higher than sucrose, may offer a good alternative to sucrose. It is worth highlighting that the main characteristics that affect the quality of sweet spreads, like rheological and sensory parameters, depend on the amount and type of fats and sugars employed in it. However, when the sugar and fat content of a food product is modified, the chemical physical and sensory parameters may be affected. Based on the above, the aim of this study was to develop and optimize a sweet pistachio spread formulation sugar- and palm oil-free. Response surface methodology (RSM) was used to identify the optimal pistachio spread formulation with olive oil-based oleogel and Stevia with quality parameters in terms of viscosity, spreadability and oil binding capacity comparable to the palm oil and nut-based spreads available on the market. Results revealed that in sugar-free formulation the oleogel, as well as whey proteins and skimmed milk powder, play a key role in the production of high-quality sweet pistachio spread.

Poster

Fat and texture of plant-based meat analogues produced by high moisture extrusion: a rheology-based approach to optimize pilot-scale trials

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Current environmental concerns and consumer trends have driven Food Industry towards the development of plant-based meat analogues (PBMAs) to mimic animal meat. Plant proteins carry off-flavors and lack the fibrous structure (FST) of animal meat, posing challenges in product development. In animal meat, the fat content and marbling significantly impact the sensory attributes, but the incorporation of lipids into high moisture extrusion (HME) formulations tends to deter the formation of FST. This work explored the effect of fat addition (soy-bean oil, SBO, and soy-based vegetable shortening, SBF) in the mechanical properties (storage modulus, G', and, loss modulus, G'') of a high protein (66% d.b.) soy protein-wheat gluten PBMA formulation under simulated HME conditions (high shear, heating, 40-140°C in the barrel, with subsequent cooling to 25°C in the cooling die). Three formulations were tested: only-protein control (F0), added-SBO (F1), and added-SBF (F2). All contained 35% of solids and were mixed at low shear. For F0, contained 65% water, whereas F1 and F2 contained 60-63% water and 2%-5% lipid. Rheological testing was conducted in a strain-controlled rheometer, equipped with a high-pressure cell with vane rotor. The G' and G'' were used as indicators of structural strength as function of the formulation, temperature and shear rate. The thermal transformations of SBO, SBF, and the formulations were analyzed by Differential Scanning Calorimetry (DSC).
As expected, the behavior during heating was similar for all treatments ($p<0.05$). On the other hand, while cooling, the impact of the oil (F1) on the G' was shown by two modulus cross-over points, were G" was greater than G' (around 90°C and 60 °C), indicating that the sample shifted between solid-like and liquid-like structure. This behavior indicates that SBO will probably hinder the development of FST of gelled protein. There was no difference between F0 and F2 ($p<0.05$) during cooling, possibly due to the re-crystallization of SBF (Tpeak= 29.3±0.4°Coccurs in the same temperature range. These results encourage the exploration of solid fat in HME-PBMAs. Finally, the methods used helped reduce the number of formulations selected for the costly pilot-scale trials, consequently, optimizing the process and product design.

Poster

Production of dried sourdough by spray drying and fluidized bed process

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With the revival of slow bakeries, sourdough is gaining notoriety. Managing this sort of ferment, however, presents some challenges, including handling complex microbiota with yeast and lactic acid bacteria and a limited shelf-life, which implicates in a laborious and frequent sourdough maintenance. Drying is one of the most common techniques for extending food products' shelf-life and two of the most revered unit processes are spray drying (SD), which has been previously used for drying sourdough, and fluidized bed drying (FB), with no record of usage with sourdough. This study aimed to produce a stable and viable dried sourdough. The sourdough (SR) was prepared by mixing the sourdough starter, water and flour in proportions 1:2:3 and incubated at 20ºC for 6 h. For FB, 35 % of corn starch was added to SR to obtain pellets through extrusion and spheronization, proceeding to a 1 h drying process at 40 °C. The same starched dough (SRA), diluted with distilled water in proportions 1:1, was fed to SD and dried for 1.5 h at 140 °C. Moisture content and water activity as well as the sourdough's fermentative power, which was tested using a simple rehydration process for dried sourdough with 60 % saline solution and 1 % sucrose incubated at 28 ºC for 22 h, were monitored before and after each drying process. Drying 400 g of SRA provided an efficiency of over 98 % in FB, while it was limited to 25 % in SD. Both dried SRA presented viable microbiota, water activity below 0,6 and water content around 8 % and 4 % for fluidized and spray dried sourdough, respectively. FB process proved more efficient and quicker than SD, in addition to granting higher microbiota viability, resulting in greater volume increase once rehydrated. These results suggest that even with a low residence time, SD's high temperatures may have affected the microbiota's survival rate. In summary, dried viable sourdough may be obtained using different drying technics, being FB the operation that better preserves the microbiota.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Red sorghum flour protein extraction: influence of pH and temperature on yield, physicochemical and emulsion formation properties of the protein extracts

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This work aimed to obtain sorghum proteins by alkaline extraction and evaluate the physicochemical and functional properties of the concentrates. Protein extraction yield was evaluated in different pH conditions (8, 10, 12) and temperatures (20 °C and 40 °C). The sorghum protein concentrates (SGPC) were characterized for proximate composition, surface charge, solubility, surface hydrophobicity, SDS-PAGE and emulsifying activity (EAI) and emulsion stability (ESI) indexes. The extraction yields varied between 15.69 – 58.52 %, reaching maximum value in more alkaline medium and higher temperature. The protein content of the concentrates obtained in pH 8, 10 and 12 was 38.98, 44.59 and 43.02 % d.w., respectively. Zeta potential curve showed similar behavior for all extracts and the isoelectric point was around pH 3.7. The protein solubility in neutral condition for SGPC - 12 was significantly higher (64.49 %) than the other extracts (14.19 % and 17.50 %), which was related to reduction in protein surface hydrophobicity. SDS-PAGE revealed mainly kafirin bands in the SGPCs, in addition to globulin and glutelin fractions. Finally, the EAI were similar between the samples (average 117 m^2/g) and the ESI was 14.76, 15.27 and 20.80 min for the SGPC - 8, 10 and 12, respectively. In extreme alkaline condition (SGPC - 12) an unfolding and refolding of the proteins probably resulted in a more flexible conformation, improving solubility and the emulsion stability, and reducing exposure of hydrophobic patches on the protein surface. The activity and stability indexes showed that the unpurified concentrates had the ability to form and stabilize oil-in-water emulsions with EAI and ESI comparable to other protein sources such as soy and pea. Alkaline extraction is adequate to produce protein products for food purposes without needing organic solvents. The results presented in our work point out that sorghum is an interesting source for the development of plant-based food ingredients.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Optimization of processing of broccoli and radish mixture sprouts for the obtaining high content of sulforaphane

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Sulforaphane has many positives - antibacterial, antioxidant, anti-inflammatory and anti-cancer; recent studies have also shown a positive effect in children with autism. Bound in the form of glucoraphanin, sulforaphane is a stable substance, non-toxic to the broccoli plant. It is released by the action of myrosinase, an enzyme which is readily available in white radish sprouts, where it is usually found in higher quantities compared with broccoli. The purpose of the present work was to experimentally verify different approaches to heat treatment of broccoli and radish sprouts to release sulforaphane. The main objective of the testing was to verify the effect of different combinations of sprout heat treatments and holding times on the amount of sulforaphane released in the resulting lyophilisate. Using appropriate thermal procedures and the addition of radish naturally containing myrosinase, up to 5-fold higher amounts of sulforaphane were obtained in the broccoli-radish mixture lyophilisate (8.51 ± 0.34 mg/g) when compared with the untreated broccoli lyophilisate (1.48 ± 0.04 mg/g). A correlation equation was obtained for calculating the content of sulforaphane in the sprout mixture lyophilisate based on the process parameters. The obtained broccoli-radish lyophilisate can be suitably incorporated into selected foods.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effect of freezing temperature on cooling rate and quality of salmon: experimental research and numerical modeling

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Proper thermal processing allows to deliver healthy and quality foods to the consumer. The evolution of the temperature of the salmon meat during the freezing process affects the microstructure and quality parameters such as color and texture due to the formation of ice crystals in the food. Consequently, the objective of this investigation was to study the ice crystal size, color, and texture of Atlantic salmon samples frozen at -20°C and -80°C. A three-dimensional unsteady conjugate model of turbulent heat natural convection in the air inside the freezer and heat conduction with the phase change of water in the salmon meat allowed to estimate the cooling rate and predict changes in food quality parameters. Then, the methodology used incorporates experimentation and computational modeling of the salmon freezing process. Color and texture profile analysis were carried out on the frozen salmon samples and the results were compared with a fresh sample stored at 4°C. In addition, a histological technique was used to observe by light microscopy the spaces left by the ice crystals in the salmon tissue during freezing. On the other hand, the Finite Volume Method with the SIMPLEC algorithm and a non-uniform structure staggered mesh solved the conjugate turbulent mathematical model, including the continuity, linear momentum, energy, and k - ? turbulence model equations. The numerical simulations were performed with an in-house code written in Fortran. The experimental results indicated that when the freezing temperature decreased, a whitish effect was observed on the surface of the food and the size of the ice crystals decreased by an average of 40%. Lightness increased from 15% up to 30% when the food was frozen at -20°C and -80°C, respectively. The numerical results obtained include the unsteady description of streamlines, temperature, cooling rate, and dimensionless heat flux, calculated in terms of the local Nusselt number on the meat surface. The conjugate model allowed to relate the calculated freezing rate with changes in the luminosity of salmon samples using the experimental results to predict the changes in the color of the pieces of salmon which is a key quality parameter in salmon price.

Poster

Smoked pork loin with ultrasound-assisted curing: physicochemical and sensorial effect

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TITLE: **SMOKED PORK LOIN WITH ULTRASOUND-ASSISTED CURING: PHYSICOCHEMICAL AND SENSORIAL EFFECT.**

ABSTRACT
The objective of this study was to evaluate the impact of high intensity ultrasound (HIU) assisted brining on the physichochemical characteristics and consumer prefrence of smoked por loin (*Longissimus dorsi*, LD). LDs were cut on slabs of 5 x 8 x 2,5 cm (lenght x width x height). Two brines (5 and 10 % NaCl) and two methods (static TC and high intensity ultrasound, HIU f52or 30 min). After curing, the samples were smoked, cooled, vacuum packed and ripped for 7 d at 4 °C. Weight, pH, percentage of NaCl, water holding capacity (WHC), shear force and CIEL*a*b colour, Chroma and Hue angle were evaluated in post-brining samples and smoked samples. Sensory analysis was performed to evaluate preference in appearance, taste and texture charecteristics. Weight and NaCl increased in samples post brining. However, smoked pork samples were not significantly different among treatments. The smoked sample became more yellow and less red. Consumers preferred TC smoked pork on appearance characteristic. HIU mproved cured pork meat. It is necessary to consider the posterior treatment that the cured meat will undergo, since part of the weight gain is lost during the smoking process.

KEY WORDS: **Curing, mass transfer, hugh intensity ultrasound, brine, sensory analysis, smoked pork.**

Poster

RHEOLOGICAL STABILITY OF PISCO COM LUCUMA CREAM

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RHEOLOGICAL STABILITY OF PISCO COM LUCUMA CREAM
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A research work was carried out on the rheological stability of pisco cream with lucuma, it is a product that contains pisco, milk, lucuma, sugar and stabilizer, and is consumed as an appetizer in festive gatherings and that when stored suffers a change in stability. Therefore, a stabilizer has been used in different concentrations in order to determine the best time without suffering rheological stability changes. The experiments have been carried out in the Laboratory of the Professional School of Agroindustrial Engineering of the National University of Moquegua - Peru. Initially, the stability is uniform for the different treatments in duplicate and it is stored for fifty days in the environment, after which its rheological characteristics will be analyzed. It is expected that one of the three treatments carried out will present a desired stability in storage time.
Keywords: Pisco, Cream, Lucuma, Rheology.

Poster

Transfers and reactions modelling of aroma compounds in coffee beans during fermentation

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The aroma quality of coffee is strongly related to the chemical composition of the beans. This depends on the production conditions, the coffee variety and the post-harvest treatment applied. When wet post-harvest treatment is used, the quality of the coffee is often inscreased. Wet processing combines several unit operations: depulping, fermentation and drying. It is known that the fermentation process improves the quality of coffee drink. However, the mechanisms of aroma transfer and reactions involved in fermentation are not yet established.
Therefore, the objective of this study is to use a modelling strategy to characterise the mechanisms involved. To this end, kinetic models of increasing complexity were deployed to identify the mechanisms affecting the evolution of the concentration of three aroma compounds (isoamyl acetate, 2-phenylethanol and butanal) classically produced by yeasts and found in coffee beans. Simulations of the wet treatment were used to identify the parameters of the models by comparing them with the experimental kinetics carried out for four media (M1: dehulled beans, M2: demucilaginated beans, M3: depulped beans, M4: depulped beans with yeast), at 25 °C using labeled aroma compounds. The transfer of 2-phenylethanol was well represented by a model taking into account an evolving resistance of the periphery of the seed (R^2 = 0.98). The more complex evolution of the isoamyl acetate and butanal contents required the use of a model combining two first-order reactions in parallel (R^2= 0.87-0.66 and R^2= 0.80-0.67, respectively). These models provide insight into the mechanisms involved during fermentation. In the futur, coupling these models with kinetic models of yeast aroma production should allow a better definition of optimal fermentation conditions.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Osmotic dehydration of ginger using maltitol solutions as emerging osmotic agents

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Ginger is a rhizome with refreshing sensory characteristic due to its pungency, besides of its high contents of bioactive compounds. The high moisture content in the raw ginger results in a high level of perishability - thus, generating consumer unpleasantness when acquiring it few days after harvesting or minimally processing. In this sense, food industries have been evaluating processes that increase the shelf life of food, such as osmotic dehydration. Although it is considered a conventional technique for reducing moisture content, the quality of the resulting product can be improved with the use of non-conventional osmotic solutions. For this, maltitol was used in this study as a sweeteners with reduced calorie content to perform osmotic dehydration of ginger. Saturated solutions of maltitol at 298.15, 308.15, 318.15 and 328.15 K were applied with processing times ranging from 1 to 24 hours. Ginger samples cut in a plate format (4.2 length x 4.2 width x 0.5 cm thickness) were immersed in the saturated solutions without mechanically agitating using a 1:10 ratio for ginger to saturated osmotic solution. After 24 hours of process, water losses by the ginger samples obtained ranged from 16.45±1.52% to 25.18±2.52% for 25 °C and 55 °C, respectively. The solids gain reached values of 9.12±1.18% at 11.45±1.51 at 25°C and 55°C, respectively. The increase in processing time caused greater mass transfer by keeping osmotic solution saturated over the processing time, leading to the maximum gradient for mass transfer between the food and the osmotic solution. In addition, the increase in temperature caused a decrease in the viscosity of the solutions, also facilitating the diffusion mechanisms of maltitol molecules into the food matrix. The fitting procedure showed a good fit accuracy of the Peleg model to the experimental data, predicting water loss and solid gain with $R2 \geq 0.994$; $RMSE \leq 0.408$ and $R2 \geq 0.995$; $RMSE \leq 0.222$, respectively. It is, then, concluded that temperature and time of osmotic dehydration play an important factors when dealing with saturated solutions during osmotic dehydration. Moreover, maltitol demonstrated to be a potential sweetener to be used in osmotic dehydration for producing low-calorie food products with extended shelf-life.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Fluorescence spectroscopy as non-destructive test to predict quality change of fresh-cut apples

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Fluorescence spectroscopy is a non-destructive analytical technique that can be used to quantify food quality changes as function of process or storage condition. Therefore, the aim of this work was to evaluate if fluorescence spectroscopy can be used as rapid test to evaluate and predict quality change of fresh-cut apples during storage. To this end, the specific objectives of the work were: to correlate fluorescence excitation emission matrix with chemical-physical properties of fresh-cut apples and to use a kinetic model approach to describe the factorial components, color, and nutritional quality indicators as function of time and temperature. Thus, fresh-cut apples were stored for 16 days at 4°C, 10°C and 15°C and at different storage times the color (L*, a*, b* and ΔE), the content of vitamin C and fluorescence spectra were evaluated. PARAFAC analysis has been conducted on the fluorescence spectra and was validated for five different components, each associated with specific fluorescence regions. Quality indicators were analyzed by nonlinear regression analysis to estimate kinetic constant and Activation Energy (Ea). Results showed that the ratio between component 1 and component 2 (C1/C2) was high related to quality changes of fresh-cut apples during storage. Pseudo-first order kinetic model and Arrhenius equation well described the evolution on fresh cut apple colour, vitamin C and fluorescence parameters as function of time and storage temperature. The value of kinetic constant of C1/C2 quality index parameter (0.40 day-1) was higher than colour or vitamin C constant (0.12, 0.13 day -1). However, Ea of florescence quality index was of the same order of magnitude of colour quality index (DE) ones, respectively 86±3 kJ/mol and 76±4 kJ/mol. Whereas, Ea of vitamin C degradation showed a lower value of 16±2 kJ /mol. In conclusion, the fluorescence analysis can be used as non-destructive test to study quality changes of fresh cut apples. The spectra can be used to predict fastest quality changes in the products. However, further studies are needed to further correlate spectra and to define the critical level of acceptability to properly predict the product shelf life.

Poster

Microwave-assisted pasteurization of mango pulp and nectar: thermo-physical, electrical and dielectric properties and inactivation kinetics of pectin methylesterase

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Continuous flow microwave heating has proven to be an important option to heat exchangers in the thermal processing of liquid foods because of the fast volumetric heating, low wall temperatures, high energy efficiency and use of electricity from renewable sources. The aim of this study was the microwave-assisted pasteurization of mango puree and nectar (Palmer variety). To support process design and operation, the thermos-physical, electrical and dielectric properties were determined and successfully correlated with temperature: density (pycnometry) thermal conductivity (concentric cylinders), heat capacity (DSC), rheology (parallel plates, coaxial cylinders), electrical conductivity (conductivity meter), relative electrical permittivity and dialectic loss factor (coaxial probe). Ionic contribution to microwave hearting varied between 20 and 70% at 915 MHz and between 5 and 50 % at 2,450 MHz, with a favorable increasing penetration depth only at 2,450 MHz. Samples was thermally processed at different time-temperature combinations (2 to 100 s, 50 to 85 °C) using conventional heating (water bath) and microwave heating (focused mw reactor at 2,450 MHz) recording the temperature history with a fiber optic sensor. Conditions were selected to obtained a residual activity of enzyme pectin methylesterase (PME) between 3 and 97 %, assessed by the titration method. The first-order with two fractions kinetic model was well adjusted to the data, with lethality integration for each treatment, suggesting the presence of two fractions with very different thermal resistances, as is usual for PME. Negligible difference in inactivation rate was observed under microwave heating (only thermal effects). Support: FAPESP 2013/07914-8, CNPq 169888/2017-7, 316388/2021-1.

Poster

Dehydrofreezing : Conventional versus Intensified Processes towards better quality attributes of strawberry fruits

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Freezing and Thawing processes result in severe damage of the integrity of product's cell structure due to the formation of ice crystals, especially for fruits with high initial water content, such as strawberry fruit. Dehydrofreezing, a process which involves water partial removal before freezing has been proposed in order to reduce the negative impacts of conventional or even accelerated freezing. For this purpose, strawberries fruits were subjected to convective air drying of 40 °C and 3m/s to reach different water content levels of 1, and 0.3 g H_2O/g db. Freezing profiles obtained at various freezing rates (V1, V2, and V3) for different water contents allowed the main freezing characteristics such as the Initial Freezing Temperature (IFT), the Practical Freezing time (PFt), and the Specific Freezing time (SFt) to be assessed. On the other hand, quality attributes were estimated through the assessment of thawed water exudate (TWE g H_2O/100 g db), color, texture (maximum puncture force as index of firmness) and some phenolic compounds: water content had great impacts on thawed water exudate (TWE). Hence, the lower the water content, the weaker the TWE. Moreover, the partial removal of water by air drying before freezing remarkably reduced the negative impact of freezing/thawing processes on final strawberry color. Decisively, the firmness of strawberry fruit increased with the decrease of water content level. Finally, the obtained results showed an improvement of phenolic compounds retention with the increase of drying intensity, to obtain the highest levels of phenols, flavonoid, and anthocyanines

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Use of the addition of antimicrobials, bioprotectors and direct acidification to extend the shelf life of sheep and goat cheese whey under refrigeration

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Sheep's cheese whey (SCW) and goat's cheese whey (GCW) are by-products of cheese production and, on small farms, are not used properly due to small volumes and lack of knowledge on how to process it. Thus, these by-products are destined for animal feed or discharged, reducing the income of producers, and causing environmental concerns. Microbiological stabilization with consequent extension of shelf life is the first step to add value to these products. Considering the need of simple solutions for application in artisanal production, we evaluated the effectiveness of nisin, Lacticaseibacillus casei addition as bioprotective culture, and direct acidification with lactic acid (up to pH 4.5, 3.5, and 2.5) as tools to guarantee the stability of pasteurized (75°C/5min) SCW and GCW for 28 days at 7 °C. The results showed that nisin and acidification at pH 3.5 and 2.5 maintained mesophilic and psychrotrophic bacteria counts below 1 log CFU/mL, with stable pH and acidity during samples storage. Inoculation with L. casei was also effective, reaching 7-8 log CFU/mL and protecting the samples with slight (SCW) or no acidification (GCW); whereas samples with pH 4.5 and control (only pasteurized) had a slight (~2-3 log CFU/mL) and expressive growth (≤8 log CFU/mL), respectively. Regarding the physical stability measured in the static experiment, all samples destabilized, but those acidified at pH 3.5 and 4.5 had a higher rate of phase separation and greater cream formation (up to 30%) and sediments (up to 6 %). Conversely, the particle size data showed little difference between treatments (0 and 28 days of storage) for both whey sources, suggesting that the interactions of the particle responsible for physical stabilization were disrupted by agitation performed before the particle size measurement. The final evaluation of the results highlighted the addition of nisin and the inoculation of L. casei as effective barriers to prevent SCW and GCW spoilage, while acidification needs to be carefully evaluated due to the high amount of acid (6.6-7.7 v/v of lactic acid 40%) required to reaches pH 2.5, the low stability observed at pH 3.5 and 4.5, and vulnerability of samples to contamination at pH 4.5.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Coupling between flow, heat transfer and rheological properties of starch suspensions in a tubular heat exchanger

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Starch is a polysaccharide found in large quantities in plants, in which it is stored in dense micrometric granules. It is widely used in food formulations as a colloidal stabilizer, thickener and water-retention ingredient. Starch granules absorb water and swell above a temperature of around 60-70°C (gelatinization). We propose a study of the gelatinization of starch suspensions combining kinetic modeling of individual starch granules, pilot-plant scale experimentation and numerical modeling. At the individual starch granule scale, the swelling as a function of temperature and time is predicted by a kinetic model based on real-time microscopic observations previously developed in the laboratory. However, when this transformation is conducted in industrial steady-state equipment, the local quantities (residence time and temperature) can significantly diverge from the average operating conditions due to the fluid flow profile and heat transfers. Moreover, the changes in the rheology during the starch gelatinization will modify the heat- and momentum-transfer coefficients. To better understand the resulting coupled phenomena, we have used a pilot-scale heat exchanger. A control system allows to select the temperature at the center of the pipe at different points along the duct and a volumetric pump to select the flow rate and thus the mean residence time. According to the previously established kinetic model, different operating conditions (flow-temperature) were chosen to theoretically lead to the same swelling degree. The gelatinized suspensions obtained were characterized showing that fast treatments at higher temperatures lead to more viscous products corresponding to more strongly swollen starch granules. This can be explained by a coupled effect related to heat and momentum transfer: heat flow results in a temperature gradient from the walls, in the vicinity of which the fluid elements move more slowly, to the center of the tube, in which the fluid elements are subject to less heat treatment. As consequence, these gradients result in very different residence time/heat treatment depending on the position (distance from the wall) of the fluid element considered. Numerical modeling of the coupled phenomena (fluid flow, heat transfer, gelatinization and rheology) is performed and the resulting model predictions are compared with the experimental results.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Review of Production of Konjac Glucomannan from Amorphophallus sp.

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Glucomannan is a major component of various species of the genus Amorphophallus belonging to the family Araceae such as A. konjac, A. albus, A. bulbifer, A. variabilis, A. muelleri etc. This genus is native to mainly tropical regions in South and Southeast Asia, Africa and Polynesia. Glucomannan is obtained from the subterranean tubers of the plants called corms.
Konjac glucomannan (KGM) is a polysaccharide. It is composed of β-1,4 linked D-mannose and D-glucose residues with reported ratio of 1.6:1. Actually, ratio differs with konjac breeds There are acetyl groups attaching randomly to C-6 position of the saccharide units along the molecule approximately 1 per 19 sugar residues, and some side chains linking to mannoses by joint C-3.
Glucomannan has been consumed in Japan for centuries in the form of a jellied food called 'konnyaku'. Nowadays, 'konnyaku' is still consumed as a food for health maintenance since it has beneficial nutritional effects for human health. Hence, it is suitable for health food manufacturing and is an important gelling agent for the food industry and also for pharmaceutical industry where it is used for microencapsulation.
Once the corms have been harvested, they will be processed into the form suitable for different applications in the food or pharmaceutical industry. The main steps of processing consist in dehydration, grinding into a powder, polishing of the remaining starch and removal of the impurities. The production of the glucomannan flour from the fresh tubers is carried out by dry or wet milling process. In the dry milling process, the corms are cut into slices and dried by a flow of hot air. This was traditionally carried out by sun drying but given quality losses in this process, it has been replaced by mechanical dryers. Dried chips ground into a powder using a turbo milling system incorporating air classification. In the wet drying system the corms are blended with ethanol solution leading to the extraction of high-degree purified glucomannan.
This paper is reviewing the details of the industrial-scale extraction and the applications of different grades of konjac glucomannan flour.
Keywords: konjac glucomannan, wet extraction, dry extraction, microencapsulation

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Proteolysis in fish meat during sous vide cooking: Peptidomic analysis of salmon mie cuit

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The cooking of raw materials (meat and fish) in a vacuumed state at precisely controlled temperature is called "sous vide cooking", which can improve the flavor and texture. Recently, sous vide cooking is increasingly applicable in many food industries worldwide. Improvement of tenderness during sous vide cooking has been discussed by focusing on thermal protein denaturation. Many previous studies have already suggested mathematical models of thermal protein denaturation kinetics and predicted the textural changes of meat depending on heating temperature and time. On the other hand, effects of proteolysis on the tenderization have not been explored well. Some proteases which are activated at low temperatures (<30°C) are found in meat and fish fillet, thus these proteases may also contribute to the tenderization. In this study, we focused on mie cuit which is famous as one of the fish dishes prepared by sous vide cooking. The relationships between cooking temperature and proteolysis in Atlantic salmon (Salmo salar) fillet was investigated.
The small fillets (15-20 g) were boiled in sealed plastic bags at 30, 40, 50, 60, or 85°C for 15 min. The samples were immediately cooled in ice water after heating and used for peptide extraction. The extracted free peptides were desalted and subjected to quantitative peptidomic analysis with nano LC-ESI-MS/MS. The database search was performed with the protein dataset of salmoniforms obtained from NCBI.
As a result of peptidomic analysis, glycolytic enzymes, myofibrillar proteins, and collagen were identified as degraded proteins. Less free peptides were found in in the salmon fillet cooked at 60°C or 85°C compared to the raw fillet. This result indicates that free peptides can be lost by water leakage due to thermal shrinkage. A lot of free peptides derived from actin was generated in the salmon fillet cooked at 50°C. Comparison of the quantified actin degraded peptides showed that the c-terminal ~20 residues of actin was frequently cleaved in the salmon fillet cooked at 50°C. Salmon mie cuit is generally cooked at 45-55°C. The results suggest that the proteases activated at 45-55°C can tenderize salmon meat by degrading actin.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Microstructure characterization of infrared-treated soybeans using X-Ray micro-computed tomography

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Thermal treatment such as infrared micronization is one the important unit operations in the processing of legumes and soybeans. The heat causes significant microstructural changes inside the kernels, resulting in the development of micro-cracks and air pores depending on treatment conditions such as initial moisture content of kernels and infrared radiation time. The mechanism of such microstructural transformation is not well understood due to the lack of quantitative data. The X-ray micro-computed tomography (micro-CT) has been proven to be a powerful non-destructive tool to explore the microstructure of biological samples, including legumes seeds. Therefore, in this study, the microstructure of soybeans with initial moisture contents (12, 16, 20, and 24% w.b.) and treated at different micronization durations (60, 90, and 120 s) were studied and related to quality parameters such as water absorption, hardness of non-cooked and cooked samples. The results from water absorption tests demonstrated no significant difference ($p > 0.05$) between the moisture absorbed for 60, 90, and 120 s micronization. Texture analysis was associated with the force required to break individual seeds. The highest texture degradation was achieved after 60 s of treatment on 24% moisturized seeds. Results of 3D multiscale analysis have shown an increase in porosity with increasing infrared treatment time. Overall, the qualitative and quantitative analysis provided in this study may serve as a basis for the development of improved food processing techniques such as roasting, milling, and storage.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Temperature and water activity dependence of ?-galactosides degradation in cowpea bean during steeping process

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Pulses top the list of sustainable crops due to their high balance between nutritional quality and negative environmental impacts on greenhouse gas production, land and energy use. Among the different varieties of pulses, cowpea beans are a popular ingredient in traditional dishes from West Africa and Latin America, requiring a hydro-thermal pre-treatment before cooking or frying. For a transition towards more sustainable food systems, it is of particular interest to reduce the compounds with negative effects (*e.g.* α-galactosides and phytates) of cowpea beans during the hydro-thermal treatment, notably the steeping process. For that, the kinetics of α-galactosides degradation of cowpea beans were investigated under different process conditions (temperature and water activity). To assume isothermal conditions, experimental data were obtained from samples of cowpea powder at different water activities (0.7, 0.8, 0.9 and 1.0) placed in polyethylene pouches and treated under combinations of intermediary temperatures (45, 50, 55 and 60 °C) and treatment times (5 min ≤ *t* ≤16 h). The α-galactosidase activity was quantified by measuring the liberation of p-nitrophenol from p-nitrophenyl-α-D-galactopyranoside for cowpea beans treated under different conditions. A first-order kinetic model was fitted to the activity data at $a_w = 1.0$ ($k_{ref} = 0.05$ min at 55 °C and $E_a = 265$ kJ/mol); whereas, the enzymatic inactivation kinetics at other water activities (0.7, 0.8 and 0.9) were better described by the first-order kinetic model with a thermo-resistant fraction, suggesting the importance of water availability to α-galactosides degradation reactions. Predicted inactivation curves showed a negative log-linear dependence between thermal inactivation rate and water activity, as well as the temperature dependence of thermal inactivation rate, following the Arrhenius law. These results drive insight into the importance of water activity on the degradation of α-galactosides, resulting in implications for the representation of the diffusion-reaction phenomena inside the pulses during the steeping process.

Poster

Study of the chicken carcass surface cooling during the slaughter air-ventilated chilling step

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Campylobacter is the most common bacterial foodborne pathogen in Europe. Poultry meat is considered the main source of human campylobacteriosis. To mitigate the health risk, the level of *Campylobacter* contamination of poultry carcasses must be reduced. Acting at the slaughter stage and more particularly at the stage of carcass chilling by ventilated air has been highlight by the French and European food safety authorities during *Campylobacter* exposure assessment as a possible risk mitigation strategy due to the sensitivity of *Campylobacter* to cold, desiccation and oxidative stress.

The aim of this study was to evaluate the influence of the physical parameters of the chilling stage (air temperature and velocity) on the surface temperature of broiler carcasses.

A plastic broiler carcass model was first designed by 3D printing after 3D scanning of a chicken carcass and then fitted with sensors positioned at the neck, tenderloins, wings, front and back of the carcass thighs. The sensors consisted of small aluminium cylinders into which thermocouples were inserted. The model was heated to a temperature of 36°C, then installed in different orientations in a cooling cabinet in which the temperature and air velocity varied between -5 and +5°C, and between 1 and 4 m.s^{-1}, respectively. The sensors were calibrated to determine the convective heat transfer coefficient for comparison of their response with the operating conditions.

Decreasing the target air temperature increased the cooling rate of broiler carcasses, but did not change the heat transfer coefficient. Experimented at an air speed of 1 m.s^{-1}, the heat transfer coefficient of each sensor varied according to the orientation of the model and thus the direction of the air flow. The neck, wings and back of the thighs were the most favourable areas for heat transfer. Tested only for the sensor in the ventral position of the model, the heat transfer coefficient increased with the air velocity.

Coupled with predictive models of *Campylobacter* cold inactivation, these preliminary thermodynamic results could be used to determine the most suitable parameters to reduce the level of *Campylobacter* contamination during the air-chilling step.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Powder Morphology Development during Spray Drying

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Spray drying is widely applied in food industry to convert liquid formulations into powder to facilitate transport and extend their shelf-life. Spray dried powders have superior quality due to their excellent reconstitution behaviour and the relative mild drying process which preserves product quality. One of the key factors in determining product quality is the morphology of the primary powder particle, which influences reconstitution behavior and flowability. However, the complex phenomenon of morphology development, especially as function of material composition and drying conditions, has not been topic of in-depth scientific study. Better understanding of morphology development is expected not only to contribute to improved powder quality, but also to improved efficiency of spray drying operations. Specifically, lack of control on particle formation and stickiness behavior increases risk of fouling in spray drying towers, which leads to extended downtime and loss of material. The main objective of our research was thus to create mechanistic understanding of morphology development of drying droplets, which was divided in two main research questions: 1) How are skin formation and subsequent morphology development affected by the drying conditions or product formulation? 2) Can the rheological properties of components at high concentration explain the morphology development during drying? To answer these research questions multiple methods were employed. Single droplet drying was used to observe morphology development and rheology revealed the behaviour of concentrated systems explaining skin formation. Finally, pilot-scale experiments were done to translate findings of this research to larger-scale spray drying

Poster

Hydrodynamic study of spherical and non-spherical particles in a batch rotary drum

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Rotary drums are common devices used in several industrial activities due to their capacity of providing a good material mixing performance. For instance, in food products processing, the rotary drums are employed in drying, heating, mixing or coating of granular materials. Rotary drums can be operated in order to achieve the rolling regime for the product under consideration. This regime is preferred because it provides better heat transfer conditions ensuring a high product quality. So, correctly understanding the coupled phenomena involving the product in a rotary drum is essential for make use of its maximum potential. As a previous step of a physics-based computational modelling of these phenomena, here we assess the influence of operating conditions and the shape of granular materials on their hydrodynamic behavior in a rotary drum. For this, we choose three particles types, with similar size (few millimeters): quinoa grains, pearl pasta, and crozet pasta. The two first ones are spherical or almost; the two latter ones are expected to exhibit the same physico-chemical properties, and the third exhibits platy shape. It can be noted that both the operating conditions of the pilot unit and the particles shape can influence the hydrodynamic behavior of the particles inside the rotary drum. Usually, the granular systems found in food applications have no spherical shape and to study their flow properties can thus be more complicated than for spherical particles. The experimental protocol involved firstly the observation of the rolling regime inside a rotary drum with diameter of 84 mm, for the three particles types using image analysis, and later on the estimation of the dynamic and static angle of repose, the active layer thickness and the mixing time. The results are allowing us to study the flow behavior of materials with different shapes, contributing to the experimental validation of the rolling regime as seen by a physics-based computational modelling of these same materials using Discrete Element Method (DEM) in a rotary drum. Once validated its hydrodynamic component, our efforts will be focused on the modelling the coupled heat transfer phenomena.

Poster

Modeling the power curve of bread dough during mixing

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The food industry has multiplied the number of flour references used, which have different behaviors during kneading. The physical changes of the flour biopolymers that occur during this stage depend on the mechanical energy delivered to the dough by the kneader, developing the gluten network. Tracking the power curve P(t) provides an indicator of the kneading time to reach the optimum network structure, for processing and bread quality. However, the curves are difficult to handle because the usual method involves reading a dozen parameters at specific points, such as the maximum power of value. The objective is therefore to adjust the curve P(t) by a mathematical model to extract the characteristic parameters. The power curves obtained by mixing dough at 67% hydration on a spiral mixe,r for 36 wheat flours, are fitted by a Gaussian law (R^2mean=0.97). Four parameters are then extracted: the power at the end of frasing, the standard deviation of the curve SD, the time to reach the maximum power and the power of the dough during its texturation. They are correlated to those from the initial method but they better explain the variability of the kneading curves of the flours (Adjustment: 91.2%; Initial method: 82.7%). Furthermore, the extensibility capacities of the dough (L and G from the Chopin alveograph) are correlated with SD, which provides information on the tolerance of the flour to kneading. These results underline the importance of the contribution of dough extension during kneading. They open prospect to enlighten the rheological behavior and its relation with the hydration of the flour components.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Moisture sorption isotherms of edible insects' flours

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Edible insects have been recently studied as interesting sources of protein, fats, and dietary fiber. Their promising nutrimental and prebiotic components make them suitable for a daily consumption. Sorption isotherms are a potentially useful tool to analyze edible insects' flours stability since hygroscopic properties of food materials highly depend on their protein and dietary fiber content. Mathematical models are commonly used to describe and analyze water sorption properties of materials. Among the models, theoretical, semi-empirical and empirical expressions can be found in the current literature. In many cases, standard statistical criteria such as R^2 is not sensitive enough to determine the best model to describe experimental data. In such cases, Akaike Information Criteria (AIC) can be used to evaluate the fit while penalizing the use of parameters. Iglesias & Chirife, GAB, Oswin, Peleg, and Khün mathematical models have been used to describe the moisture sorption isotherms (25°C) of *Tenebrio molitor*, *Zophoba morio*, and *Acheta domesticus*. Specific surface area of sorption, hysteresis and relative water sorption changes were also determined. The studied edible insect's flours showed a typical BET type III, although different water adsorption and desorption capacity were observed in all samples. This type of isotherm is closely related to the chemical composition of the flours. In addition, AIC differences identified Iglesias & Chirife and Peleg as the best model alternatives to describe experimental moisture isotherms for adsorption and desorption, respectively. In terms of techno-functionality, *A. domesticus* and *T. molitor* flours showed the lowest and the highest water adsorption capacity, respectively, at the evaluated temperature. This has an important impact when dealing with stability and storage behavior, where flours with the highest retention are considered the less stable. The same behavior was observed during desorption, although these isotherms are useful for drying processes design. The hygroscopicity behavior of these samples reflects some useful techno-functional applications when used as ingredient in food formulations. Further research is needed to completely understand these sources that are currently trends in the food industry field.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Baking temperature and prefermentation effects on double-layered flat bread delamination phenomenon: is it possible to lower the baking temperature for an energy-saving perspective ?

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Double-layered flat bread is widespread in Middle Eastern and North African countries and is becoming increasingly popular in Western countries. Its oven rise with delamination during baking is a prime quality criterion for consumers. Baking is a process that involves mass, heat and momentum transfer, with high levels of coupling between them.
Special ovens at high temperatures (350 to 550°C) are needed to produce the specific structure with two layers separated by a gas pocket in-between.
The simplest baking methods of flat breads have remained almost unchanged since ancient times, which raises concerns today in terms of excessive energy consumption. Optimum baking temperatures are also not always used in commercial practice. The aim of the present study is to better understanding of the impact of heat transfer and yeast generation of carbon dioxide on the flat bread delamination phenomenon kinetic.

Different baking temperatures (300 °C, 200, 220 180 and 160°C) and fermentation times were tested. In order to follow the expansion of gas pockets, a new approache of visual appreciation was proposed (with 5 levels of delamination quality). Specific volume was measured in complement. And for a more thorough quality evaluation, the mass loss during baking, and color were also measured. In unyeasted dough, the frequency of full delamination (level 5) was clearly maximized at the highest baking temperature and level 5 was gradually replaced by lower quality levels, as the baking temperature was decreased. We assumed that as baking temperature is decreased, the evaporation becomes limited to favor the rupture of gas cell walls over a large section of the flat bread. Based on these quality levels, a conceptual scheme was proposed for the delamination process. Another part of the work consisted in the evaluation of fermentation as a step to counterbalance low baking temperatures. Results showed that it only partially counterbalanced the decrease in the baking temperature. The presentation will be concluded with some alternatives for future investigation, like partial vacuum baking, with numerical simulations as demonstration support.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Pyrolysis of sucrose and quercetin for the formation of novel food structures

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Crystal engineering through solid solutions is common in pharmaceutical drug formulations, metal alloys, and ceramics manufacturing. However, due to the organic complexity of foods, the use of solid solutions for fine tuning of structural and physicochemical properties is limited. In this study, pyrolysis was employed as the approach for developing solid solutions between the single component molecular crystals of sucrose as the solvent, and the solid-state crystalline quercetin as the solute. The presence of quercetin as an antioxidant will create new caramel polymer properties, and solve the problem of radicals and toxic degradation products found in caramel products. The objectives of this study were to: 1) Develop a new food product via solid solution processing. 2) Enhance the food safety of caramels using a potent antioxidant. 3) Establish a relationship between physical structure and polymer design. Methods: A factorial design was employed. Sucrose and quercetin mixture with 1-5% (w/w) of quercetin was heated in a tube furnace at target temperatures of 160-250°C, under nitrogen atmosphere (0.5 mL/min), for duration of 15-45 min. Results show the formation of dark brown to blackish foam products treated at and above 185°C. As the temperature increased from 185 to 250°C, the recovered mass decreased from 88% to 67%, while the height of the foam structure increased from 1 to 11 mm. Scanning electron microscopy (SEM) images showed that the pore sizes were >100µm as observed at 185°C. Control sole quercetin samples did not show melting within the temperatures studied, as expected. Quercetin melts at 316°C. Other investigations to distinguish the formation of solid solutions from composite materials include characterization methods such as volume by air pycnometry, pores size and quantity by X-ray Microscopy, crystal structure by X-ray Diffraction, thermal stability by DSC, chemical structure by FTIR and NMR, hardness, water solubility, and antioxidant capacity. Conclusion: Edible caramel foam structures have been produced from sustainable materials, with enhanced nutraceutical benefits. The significance of this study will add knowledge towards crystal engineering (the synthesis and modificatiion of crystal structures) in food applications.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effect of storage time, packaging material and MAP composition on spray-dried kefir and its reconstitution properties

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Objective:
A study on the effect of packaging material and MAP composition on the shelf?life, quality and functional properties of spray-dried kefir and its reconstitution properties.

Methods:
Kefir samples were prepared from pasteurized, homogenized, heat-treated (95°C for 5 min) bovine semi-skimmed milk, inoculated with a lactic acid starter culture and yeast (XPL-30, LAF-4, CHR-HANSEN, Denmark respectively) and incubated at 30°C until pH 4.4. A probiotic culture (BB-12, CHR-HANSEN, Denmark) was mixed in the product and four different sample treatments were followed before low temperature spray drying. Appart from the control, the effect of trehalose, at a concentration of 1%w/v, and two different low temperature storage treatments (storage at -12°C for 24 h followed by 24 h at 4°C and storage at 4°C for 72 h) was evaluated.
A selection of flexible packaging materials was studied for their effect on storage with regards to products properties. Five commercially available packaging samples with varying barrier properties, on water and oxygen permeation rates, including multilayered structures and/or metalized polymeric films with the addition of oxygen or water absorbers were studied.
Different MAP compositions were used and the samples were stored at high temperature- high humidity accelerated storage conditions in thermostatic chambers.
Kefir powder and reconstituted samples were periodically characterized based on their physicochemical, structural and microbiological properties. Physichochemical analysis involved pH, moisture content, color, particle size, particle porous structure, as well as bulk density, tapped density, flowability, cohesiveness, and insoluble matter content. Viability of lactic acid bacteria, yeasts and probiotics was also evaluated.

Results:
Based on the results, the use of different packaging materials and MAP environments affected the physicochemical characteristics of the spray dried kefir powder and its reconstitution properties during storage. The most effective materials and MAP conditions were choosen for product selfl-ife assesment.
Conclusions:
The use of proper packaging material and MAP may exhibit a protective effect on kefir microflora and the reconstituted product properties during storage and expand its shelf?life.

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Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effect of cryo-treatment and carriers on spray-dried kefir powder and its reconstitution properties

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Objective:
The present work aimed atevaluating the effect of cryo-treatmentand carriers,trehalose andfructooligosaccharides(FOS),at varyingconcentrations, on the physicochemical characteristicsof spray-dried kefir powder and its reconstitution properties.
Methods:
Homogenized and pasteurized semi-skimmed bovine milk and commercial starter cultures were used for kefir production. Heat-treated (90°C for 5 min)milk, was cooledat30°C and inoculated with the starter cultures consisting of lactic acid bacteria (XPL-30, CHR HANSEN, Denmark) and yeasts (LAF-4, CHR HANSEN, Denmark). Following fermentation (30°C until pH 4.4), a probiotic culture (BB-12, CHR HANSEN, Denmark) was added to the productand eight different samples of spray dryied kefir were prepared. Appart from the control,for comparison purposes, the effect of three different concentrations (0.5-2.5% w/v) of trehalose and FOS, added in kefir prior to dying, was evaluated alongside the effect of cryo-treatment, -12°C for 24 h followed by 24 h at 4oC,before drying. Spray-drying on an SD-8 Mini Spray Dryer (Israel) was performed at reduced process temperatures.
Kefir and reconstituted samples were analysed for their physicochemical (pH, moisture, color,bulk and tapped density, flowability, cohesiveness, water solubility index and insoluble matter), rheological (apparent viscosity, flow behavior index and elastic and viscous moduli) and microbiological (lactic acid bacteria, yeast and probioticviability) properties. Particle size distribution via laser diffraction and morphologyby confocal laser microscopy werealso assessedon the dry kefir powder and its reconstituted samples.
Results:
According to the results, cryo-treatment and trehalose proved to favour the functional and reconstitution properties of kefir powders whereasFOS addition also affected them, but to a lesser extent.
Conclusions:
Cryo-treatment of kefir and the addition of carriers (trehalose andFOS) can improve kefir microflora survival and the reconstituted product properties.

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers” (Project Number: 0075).

Poster

KEFIR YOGURT FREEZE-DRYING, PROBIOTIC FACTOR RETENTION UNDER DIFFERENT OPERATING CONDITIONS.

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Currently, the population seeks to take care of their diet, opting for foods with a high nutritional level. Fermented products such as kefir promote intestinal health and strengthen the immune and digestive systems. However, they are highly perishable foods, leading to the search for alternatives to preserve their positive characteristics and extend their shelf life. Dehydration is one of the most used methods for food preservation and shelf-life extension since it reduces the water activity in them. Within dehydration technologies, freeze-drying emerges as a striking alternative where its main characteristic is maintaining the food's organoleptic and nutritional properties.
The objective of this research is to study the kefir yogurt freeze-drying process to obtain a probiotic product with an extended shelf life.
The standardization of the fermentation process for the elaboration of kefir yogurt was carried out. This consisted of the inoculation of milk with kefir grains at two concentrations (5 and 10% w/v) and the quantification of *Lactobacillus* at different times (1, 2, 3 and 4 days). From this, the process that generates a product with a concentration of microorganisms greater than 107 CFU/ml was selected. This product was freeze-dried, evaluating two operating conditions (0.3 mbar, 20°C and 0.3 mbar, 30°C) to establish the primary drying times. In addition, the concentration of microorganisms was determined for both conditions and the one that maintains the concentration was selected. of microorganisms higher than 10^7 CFU/mL and minimize the process time.
Finally, we concluded that it is technologically feasible to obtain a freeze-dried kefir yogurt product that maintains a concentration of microorganisms greater than 10^7 CFU/mL, using a fermentation process with 10% p/p inoculum at room temperature for 4 days and a freeze-dried process at 0.3 bar and 30°C for 5.8 h.

Poster

EFFECT OF CHEMICAL AND PHISICAL PRETREATMENTS ON DRYING OF WHOLE TOMATO FRUIT (DATTERINO TOMATO)

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The tomato "Datterino" is a new tomato hybrid of small size derived from an interspecific cross between *Lycopersicon lycopersicum, Lycopersicon pimpinellifolium* and *Lycopersicon chesmanii*, that was recently introduced on the market, arausing great consumer interest for its consistency and degree of sweetness. The Datterino consumption is mainly fresh while, processed products like concentrated juice and pulp needs high-cost technology for good quality products. Therefore, development of low-cost processing methodologies to produce shelf-stable products is the first objective to satisfy both the competitive market and consumer demand. Food drying is a most important process for preserving agricultural products which allows safe storage over an extended period. Nowadays, diverse drying techniques like hot-air drying, solar-tunnel drying, microwave drying, and freeze-drying are among the novel and sophisticated methods proposed for to dry and preserve tomatoes. However, all the drying processes applied to tomatoes, due to the low moisture permeability of peel, involve cutting or peeling the fresh tomatoes that affect negatively the organoleptic and nutritional qualities during the drying phase.
This work aims to evaluate the effect of different superficial pretreatments (sunflower oil / K_2CO_3 solution, sunflower oil / $KHCO_3$ solutions and hexane) to remove the wax on the peel surface of the tomato with the aim to dry whole tomatoes quickly preserving the organoleptic and nutritional qualities.
For drying, two different temperatures (40 and 50 ° C) and two different technologies (static drying and hot air flow) were compared for each superficial pretreatment. Drying speed, color, rehydration capacity and carotenoid content were evaluated. Preliminary results showed that sunflower oil/K_2CO_3 solution is the most effective pretreatment to remove wax from tomato skin and accelerate drying, even whole dried fruit showed greater rehydration capacity than samples treated with other solutions. Hot air flow drying technology was faster than static drying. Moreover, the high drying temperatures favor a greater biodisponibility of the carotenoid while the low temperatures preserve the color of dried tomato.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Microencapsulation of methyl salicylate by beta-cyclodextrin powder

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This study aims to develop encapsulation methods of methyl salicylate (MS) with crystalline and amorphous beta-cyclodextrin (β-CD). Amorphous β-CD was produced by spray drying method and had lower moisture content than the crystalline β-CD. The encapsulation was conducted by three different methods, namely direct mixing, paste and co-precipitation methods. Ethanol was used as a solvent to facilitate the penetration of hydrophobic compound to the cavity. The direct mixing method was followed by addition of absolute ethanol in ratios 1:1, 1:2, 1:3 and 1:4 (v/v) of MS:ethanol. The paste method was also followed by adding absolute ethanol in ratios 140:0, 100:40 and 0:140 (v/v) of water:ethanol. Characterisation of MS/β-CD inclusion complexes was determined by moisture content, entrapment efficiency (EE) using UV-Vis spectrophotometry, surface oil content using Gas Chromatography-Mass Spectrometry (GC-MS) and crystallinity using X-Ray Diffractometry (XRD). The results showed that the addition ethanol in direct mixing method and paste method could increase the entrapment of MS in the inclusion complexes. Furthermore, the XRD results indicated that adding water and ethanol into the amorphous inclusion complex of MS/β-CD transformed the inclusion complex into crystalline form.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Changes in soymilk protein behavior with NaCl in freeze-thaw processing

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Objective: Proteins in unheated soymilk are easily fractionated using freeze-thaw processing. The freeze-thaw soymilk is divided into two layers, the supernatant is rich in 7S (b-conglycinin) and the precipitation is rich in 11S (glycinin). The former is suitable for making soft pudding-like tofu, and the latter for hard tofu. To further elucidate the detailed fractionation mechanism, the effect of NaCl on fractionation was investigated. Moreover, to clarify the reversibility of soymilk proteins, once salted, the soymilk was desalted by dialysis and frozen and thawed.
Methods: Soymilk was made from Glycine max cv. Fukuyutaka. After the soymilk samples containing various concentrations of NaCl were frozen at −30 °C for a week, they were thawed at 5 °C and centrifuged at 3,000 ×g to separate the supernatant and the precipitate. In addition, for reversibility testing, the added salt was removed from the soymilk by dialysis followed by freeze-thawing. The particle size of soymilk was measured with a laser diffraction particle size analyzer. Zeta potential was measured with an electrophoresis light scattering analyzer.
Results: Unheated soymilk was not divided into two layers when NaCl concentration was 0.22 M or higher. When the salt concentration of the aqueous protein solution becomes quite high, precipitation usually occurs, but it's so interesting that no precipitation occurs after freezing and thawing. However, when the soymilk, which had a NaCl concentration of 0.22 M or higher, was desalted by dialysis, it was divided after freeze-thaw processing. This result suggested that the unheated soymilk proteins, once structurally changed by the addition of NaCl, returned reversibly upon desalting.
Conclusion: Proteins in unheated soymilk underwent structural changes with the addition of high salt concentrations. This caused the proteins were no longer fractionated by freeze-thaw processing. However, after desalting by dialysis, the structure of the proteins reversibly returned and the soymilk was able to be fractionated using freeze-thaw processing again.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Kinetic study: thermal destruction of Clostridium sporogenes PA 3679 in concentrated maple sap

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Maple sap is a liquid extracted from maple trees in early spring. The sap is practically sterile while extracted from the tree, however rapidly contaminated during handling and processing. Typically, microbial load varies from 104 to 106 (CFU/ml) while harvesting. Raw sap undergoes reverse osmotic process for concentration, meanwhile this operation also concentrates the microorganisms present in the sap. Enrichment of microorganisms affects quality of the sap and its derived products remarkably. Consumption of concentrated maple sap as a novel soft natural drink has increased considerably in recent years worldwide but mainly in North America. Adequate process is required in order to eliminate the microorganisms and stabilize the quality of the concentrated maple sap for further consumption. Thermal process is a safe preservation technique, however severe thermal processing may affect negatively the quality of the product for consumer acceptance. Therefore, it is important to evaluate the right thermal processing parameters such as D and Z values for a given product and processing technique. Spores of Clostridium sporogenes PA 3679 strain and selected TPGY culture media were used as a surrogate to evaluate the thermal destruction kinetic parameters of spores in phosphate buffer and concentrated maple sap (10, 20 and 30 °Brix) over a range of temperature (90 to 105°C). Concentrated sap (pH 7.91±0.15) was first filtered using a 0,45 µm filter under vacuum resulted in no microbial counts before inoculation (7 log/ml). Capillary tubes and oil bath were then used as conventional thermal processing to study sterilization kinetic parameters. D-values for concentrated maple sap varied from 6.57±0.50 to 0.35±0.06 min depending on the sap concentration and temperature with an average z-value of 7.84±0.42 °C. However, using phosphate buffer, D-values (3.01±0.16 min) were almost double of those obtained for different concentrated sap (1.58±0.13 min) at 100°C. The result of this study can be used by maple sap industries to design and perform a safe thermal process for pasteurization and/or sterilization of concentrated sap. It could also serve as a bench mark in the development of advanced green technologies such as Ohmic heating.

Keywords:, Maple Sap, C. sporogenes, Thermal Destruction, Kinetic Parameter

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Factors affecting the viscosity increase of soymilk by two-step heating

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Objective: Two-step heating (75 and 95 °C) of raw soymilk has been reported to increase the viscosity of heated soymilk and produce harder tofu. We would estimate effect of heating rate, solids content on the viscosity increase. Furthermore, the role of two main globulins, namely, 7S (beta-conglycinin) and 11S (glycinin) in two-step heating would be compared by using 7S rich and 11S rich soybeans.
Methods: Three varieties of soybeans were used in the preparation of raw soy milk: a variety containing both 7S and 11S globulins (Fukuyutaka), another one containing mainly 7S (7S rich), and the other containing mainly 11S (11S rich). The raw soymilk was heated to 80 °C as the first step and 95 °C as the second step by Ohmic heating. Viscosity of soymilk was measured with a tuning fork vibro viscometer. Surface hydrophobicity was measured by fluorescence of ANS. Protein particle content was estimated by measuring the protein concentration in the supernatant after ultracentrifugation (160,000×g, 30 min).
Results: In the case of Fukuyutaka soymilk, thicker soymilk and slower heating rate were effective in increasing the viscosity of the soymilk by two-step heating. The higher protein concentration and slower heating were considered to be associated with the greater interaction among proteins and/or oil bodies. Two-step heating enhanced the formation of protein particles, however, there was little change in surface hydrophobicity, which indicates degree of denaturation. The increase in viscosity of 7S rich soymilk was smaller than that of Fukuyutaka soymilk. Protein particles did not increase in the soymilk samples derived from 7S rich and 11S rich varieties by two-step heating, unlike Fukuyutaka soymilk.
Conclusion: The increase in viscosity of soymilk prepared by two-step heating may be related to the formation of protein particles. In addition, both 7S and 11S globulins appeared to be required for the effect of two-step heating of soymilk.

Poster

Measuring Technique for Internal Structures of Ice Cream by Cryogenic Microtome Imaging System

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The objective of this work was to measure the size, morphology, and distribution of internal structures such as ice crystals and bubbles within ice cream samples prepared with two different types of milk solids by using a cryogenic microtome spectral imaging system (CMtSIS). The CMtSIS consists of a microtome unit, a heat exchanger, an automatic high-precision XY stage, an image acquisition unit (with visible, fluorescence, and spectroscopic settings), and a 3-dimensional image processor. The CMtSIS allows for consecutive acquisition of the cross-sectional images of a frozen sample processed through a multi-slicing operation with a minimum thickness of 0.25 µm. The temperature of the heat exchanger can be adjusted from room temperature to –160 °C by regulating the flow rate of liquid nitrogen. Samples were taken from a commercial standard ice cream and a low-fat ice cream, both of which are available on the market. Bubbles in the ice cream samples were identified as defocused spots in 2-dimensional CMtSIS images due to the differences in focal distance created by vacant spaces, and ice crystals and milk solids were identified using light flux differences reflected by the different interfaces of the ice cream.

Poster

Effect of dextrose equivalent (DE) of maltodextrin (MD) on the morphology of spray-dried powder containing emulsified fish oil

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Functional food compounds such as fish oil are unstable against light, heat, and oxygen. Stability of those compounds can be imparted by encapsulating them with sugar or protein into a powder. Spray-dried powders of fat-soluble functional compounds are produced by preparing the emulsion solution of functional oil using wall material and emulsifiers, and then spray-drying them. Dextrose equivalent (DE) of maltodextrin (MD) as wall material affects significantly the morphology of spray-dried powder. In this study, effect of DE of MD on the morphology of spray-dried powder was investigated. Fish oil as core material (40wt% in the solid), sodium caseinate as emulsifier (3wt%), MD (57wt%) at various DE were used to form the encapsulant of emulsified fish oil in spray-dried powder. This solubilized solution was emulsified with polytron homogenizer and/or high-pressure homogenizer. The emulsified solution was spray-dried with the spray dryer under the following conditions: an atomizer speed of 10,000 rpm, air flow rate of 110 kg/h, the temperature and flow rate of the infeed solution at 50 ?C and 30 mL/min, inlet-air temperature 160 ?C. The spray-dried powder was washed with hexane. The surface oil in this washed hexane of spray-dried powder was measured with an TLC-FID. Surface and cross-sectional images of the microcapsules were taken using a scanning electron microscope (SEM). The vacuole diameters were measured using more than 30 the cross-sectional photographs. The number of vacuoles in the spray-dried powder was determined by analyzing CLSM images of over 300 fluorescent stained spray-dried powders. The vacuole size and number significantly depended on the DE of MD. The vacuole size and the number of vacuoles in the spray-dried powder were smaller when MD with large DE was used. The surface oil ratio?(surface-oil content to total oil) was correlated with the ratio of vacuole diameter to particle diameter.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Characterization of a blackberry snack fortified with Zinc and Folic Acid, aimed at children and pregnant women, developed by Convective Drying processes.

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The blackberry is a fruit rich in vitamins, anthocyanins, and antioxidants, it is a fruit desired for its flavor and aroma, however, due to various factors it has a shelf life of three days. On the other hand, worldwide it is estimated that 4.4% of child deaths are due to zinc deficiency, in Colombia 43.3% of children have zinc (Zn) deficiency. On the other hand, the lack of consumption of Folic Acid (FA) in pregnant women produces in newborn children weakness in the immune system, cognitive deterioration, low IQ. Given the above, the objective of this research was to develop a blackberry snack fortified with Zn and AF, through convective drying processes. The methodology included the proximal characterization of the blackberry according to the AOAC. The addition of Zn and AF was determined based on Resolution 810 of 2021 of the Ministry of Health and Social Protection of Colombia. The evaluation of convective drying was done by means of a DCC with 4 central points, the independent variables were: temperature (55-70)oC and maltodextrin content (20-30) %. The response variables were Humidity, Aqueous Activity, Antioxidant Capacity, content of polyphenols and anthocyanins, AF, Zn, firmness, and Diffusion Coefficient. The moisture, ash and crude fiber content of the blackberries was 84, 0.42 and 2.5 g/100 g, respectively. The diffusion coefficients obtained by Fick's second law varied between 1.85–6.78*10-10 m2/seg. The content of moisture, folic acid and antioxidants of the blackberry dehydrated snack were 8-10%; 3-7.3 (mg/100g); 1059 (µmol TEs/g), respectively. Likewise, the firmness of the snack ranged between 8-25N. The sensory parameters of the snack had a rating of 5. In general, it can be concluded that convective drying is an adequate methodology to develop a blackberry snack fortified with Zn and Folic Acid; the snack meets the nutritional requirements for children and pregnant women according to Colombian regulations, in addition to having good textural, proximal, and sensory properties; being the snack an alternative for the feeding of children and women in pregnancy.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effect of spray drying on technological and functional properties of albumin powder and its influence on the development of a typical Colombian dessert, "merengue."

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According to the FAO, the egg is one of the foods with the highest nutritional value due to the content of proteins, amino acids, vitamins, minerals, and essential substances. One of the egg's essential components is albumin, a primary raw material for formulating various food products. However, fresh albumin is a perishable product, making various industry applications difficult. This work aimed to develop and characterize a typical Colombian dessert, "merengue," from a powdered raw material obtained from egg albumin through spray-drying processes. The methodology included the proximal characterization according to AOAC and the quantification of amino acids by GC-M, both for fresh and powdered albumin. For the spray drying of the albumin, a VIBRASEC® brand industrial dryer was used. Technological properties for albumin powder were determined: emulsion capacity, water, and oil retention capacity, foam capacity, and stability. For the formulation of the dessert, powdered albumin, lemon, and sugar were used; the characterization of the merengue was done by textural, proximal, and sensory methods. As the main results, it was possible to establish that the protein, moisture, and ash content of albumin powder ranged between 50.06-81.38%, 6.30-7.68%, and 3.78-8.21%, respectively. The useful lysine content of the powder varied between 1.5 to 3.2g/100g of protein, and the foaming capacity values were ??between 3.97 -9.75 mL/g. Finally, it was possible to establish that the firmness of the merengue was, on average 7N. The sensory parameters of the merengue reported good taste, smell, and texture according to the qualification of the trained panel. In general, it can be concluded that it is possible to obtain an albumin powder through spray-drying processes, with technological and functional properties suitable for the development of a typical Colombian dessert, "merengue," which showed good textural, sensory, proximal, and functional characteristics, following current regulations.

Poster

Development and formulation of a strawberry dispersion fortified with Zn and folic acid: obtaining and characterizing a powder by spray drying.

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The strawberry is a fruit desired worldwide for its flavour, aroma, and nutritional content; however, it is a non-climacteric fruit, and its shelf life is three days. It is essential to look for processing alternatives for strawberries. On the other hand, the lack of consumption of zinc generates worldwide approximately the death of 4.4% of children, while the lack of consumption of Folic Acid (FA) in pregnant women produces problems in the immune system, cognitive impairment, and low IQ in new-born children. The main goal of this work was to optimize strawberry dispersion, fortified with folic acid - Zinc, and obtain a powder by spray drying. The methodology included the formulation of strawberry dispersions through a composite central design 2k, as independent variables the concentration of maltodextrin (MD) (10-30%) and gum arabic (GA) (5-15%); as response variables, water activity (aw), density, viscosity; for the fortification of the dispersion with Zn and AF, as recommended in Resolution 810 of 2021 of the Ministry of Health and Social Protection of Colombia. Spray drying was done in a Lab Spray Dryer TP-S15 spray equipment at 180oC. As a result, it was possible to determine that for the strawberry dispersion, the response variables were significantly affected ($p<0.05$) by the concentration of MD and GA. The optimal formulation of the dispersion was 18.6% (MD) and 7.4% (GA) with values 0.912, 1.12 g/ml, and 12.2 mPas, for aw, density, and viscosity, respectively. About the powder, the solubility of 95% and 14% of hygroscopicity, the particle size 200 µm, and the contents of Zn and AF, were within the range of Colombian regulations. It is concluded that it was possible to formulate, optimize and characterize a strawberry dispersion fortified with folic acid and Zn through the response surface methodology, being suitable for processing by spray drying to obtain a powder with proximal and functional properties in accordance with Colombian regulations. The above is a contribution to the transformation of the strawberry and the development of powders that can be consumed by pregnant women and children as an alternative food.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Investigation of critical process parameters to reduce the hydrocyanic acid in flaxseed presscake

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In times where “superfoods” and demands for more sustainability are becoming more vital, flaxseeds have gained a lot of attention over the last few years. This increased interest is based on the wide range of applications flax can be used for. Containing valuable nutrients such as, proteins, linolenic acid, dietary fibers, minerals, vitamins and antioxidants, flax as a raw material is mostly used in shredded form, as seeds or as an oil. Despite its beneficial nutrients, flax also contains antinutrients, such as cadmium and hydrogen cyanide most prominently, which have an adverse effect on the human health. The cold pressing of flaxseeds into oil accumulates hydrogen cyanide in the produced presscakes. As of today, these presscakes are not getting used to their full potential and the value chain bears a lot of room for improvements. The objective of the present work was to develop a procedure to reduce the hydrogen cyanide in flaxseed presscake below a critical level of 150 mg/kg.
After processing to oil, the average hydrocyanic acid content accumulating in the presscake even exceeded the limit value for animal feed of 350 mg/kg in individual cases, resulting in a restriction on its use as in food incorporations. Several pre-treatment methods to reduce the hydrocyanic acid concentration in flaxseed presscake were tested and evaluated since the quality-forming parameters such as protein content (Ø 28.7%), dietary fiber content (Ø 31.0%). Foaming, emulsification and water binding capacities tests revealed the use of this by-product in food applications, such as milk or egg alternative, after treatment. A combination of steaming at 100°C and drying at high temperature for a short time led to a significant reduction below 150 mg/kg of hydrocyanic acid. This allows safe use of the presscake in food matrices. The process was validated on a large pilot scale demonstrating the scaleability of the technology.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Describing 3D turbulent heat convection and freezing of solid foods by computational modelling: Energy, exergy and quality food issues for salmon and beef

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Demands for high quality and healthy foods requires careful processing in which transport phenomena play a key role in achieving the expected quality. Therefore, the objective of this work was to characterize the transient turbulent convective heat transfer and fluid mechanics in air inside a freezer around pieces of beef and salmon, along the unsteady heat conduction with water freezing in the foods. The method incorporated a mathematical conjugate model with temperature dependent apparent specific heat that included the liquid-solid phase change of the water content in the foods, with properties varying with temperature. Continuity, linear momentum, energy, turbulent kinetic energy and rate of energy dissipation equations were solved by numerical simulations with an in-house SIMPLEC finite volume code implemented using non-uniform staggered grids. Precise numerical results for predicting the freezing rate and heat transfer were calculated by second order accurate temperature gradients. Additionally, a local exergy destruction analysis quantified the irreversibility produced by viscous dissipation and heat transfer during freezing. The effects of position and number of blocks of salmon in a freezer on cooling rate were investigated using computational modelling. Evolution of velocity and temperature distributions in air, and temperature, cooling rate and Nusselt number (Nu) in the meat were among the main results obtained. Accurate temperature measurement by thin thermocouples in beef were in qualitative and quantitative agreement with the 3D numerical simulations. The highest cooling rate was for the food at the lower corner, and the lowest when was located at the center of the freezer. The conclusions indicates that the turbulent k-e HH model describes properly the airflow velocity and temperature, obtaining a Nu 64% higher than the laminar flow model. The three-dimensional model achieves the best adjustment to the available experimental results, reaching a Nu 28% higher than the 2D model. The entropy analysis determined a total exergy destroyed of 187 (W), mainly during the first hour of the freezing process. Finally, the conjugate computational model related the freezing rate with the luminosity predicting the changes in the color of the pieces of salmon, that is a relevant quality factor for this healthy food.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Optimization of the Hot-Fill-Hold Method for the Pasteurization of Glass Containers Filled with Acid Viscous Foods

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The hot-fill-hold process is a method for pasteurizing the container and closing when filled with acid foods to create a shelf-stable product after reaching commercial sterility. The process consists of filling containers with hot product, capping the container, and inverting it to pasteurize the container and closing with the heat provided by the product. Current hot-fill-hold processes use conservative high fill temperatures, typically 81-85ºC, that often unnecessarily overheat the product. This research aimed to determine the optimal fill temperature for containers filled with a viscous product that will heat the container primarily by conduction. For this purpose, 453, 680, and 907 grams jars were filled fully (no head-space) with tomato paste at temperatures of 87.8, 82.2, 76.7, and 71.1ºC and capped with metal lids. The containers were not inverted after filling and capping to simplify the experimental setup. The jars were furnished with thermocouples attached to the interior walls and connected to a data logger to record the internal time-temperature history of the walls, bottom, and closing area. The time-temperature history was used to calculate the cumulative lethality on the interior jar surfaces as the container initially heats up and then cools down using the finite-difference method. To estimate the temperature in different container parts, the container was divided into cylindrical finite nodes with a Δr radius and a Δz height. The container walls and bottom were considered independent nodes. An energy balance was performed in each node, assuming the radial and axial heat transfer from neighbor nodes. The cumulative lethality was calculated using the General Method with an F-value of 1.2 min at 71.1ºC (z-value=10.8ºC) for products with a pH of 4.1 or below and of 5.6 min at 71.1ºC (z-value=9.5ºC) for products with a pH above 4.1. These parameters are sufficient to achieve a 5-logarithmic reduction in *E. coli, Salmonella spp.,* and *Listeria monocytogenes*, which are the most common pathogenic targets. Results show that the target F-value can be reached at lower fill temperatures than traditionally used without compromising product safety. Moreover, this research will provide process authorities with a valuable tool to recommend filling processes.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Investigation of Electromagnetic Field Modulation via Solid State-Technology in Microwave-Assisted Freeze-Drying

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Conventional freeze-drying (CFD) is a well-established and product-friendly drying process in the life science, food and pharmaceutical industries. Microwaves in microwave-assisted freeze-drying (MFD) enable shorter process times by a direct conversion of electromagnetic energy into heat inside the product, bypassing heat transport resistances in the insulating product matrix.

Challenges associated with microwaves in MFD are the inhomogeneous energy input into the material and a frequency-dependent energy efficiency. One approach to solve these problems is to modulate the electromagnetic field over the course of drying. A new generation of solid state-microwave generators (SMG) enables this concept. SMGs allow frequency, power and phase shift of the electromagnetic field to be adapted in the sub second range by electrical control. Frequency-based control concepts have already demonstrated more homogeneous microwave heating compared to operation at fixed frequencies. During FD, however, the product constantly changes from the frozen to the dried state, which changes the interactions of the material with the electromagnetic field due to the dielectric properties.

The resulting challenge is to explore the principles of a targeted control of the electromagnetic field in MFD depending on the progress of thermodynamically complex freeze-drying. The aim is to achieve an acceleration of drying, while the quality of the product remains comparable to that from CFD.

A frequency-based control concept, developed from electromagnetic simulations in CST Microwave Studio®, was applied to MFD in a lab-scale plant. The control concept is based on the repeated search and targeted excitation of multiple energy-efficient frequencies in the ISM band 2.4-2.5 GHz. The process and product parameters were classified with respect to CFD and MFD processes with alternative control concepts. Tylose gel was used as a chunky model food.

MFD combined with the developed control concept turned out to be advantageous taking into account energy efficiency, drying time and homogeneity as well as structure retention. The ingredient retention was comparable. Furthermore MFD was able to generate products with similar or even lower residual moisture contents in comparison with CFD. Therefore, the targeted modulation of microwaves presents an approach for optimization of the already highly promising MFD process.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Foam-mat drying of prickly pear and beetroot: Drying kinetics and comparison with conventional drying methods.

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Drying is an ancient technique which still remains immensely relevant for the processing of perishable foods, like fruits and vegetables. Foam-mat drying is basically a variation of conventional hot air drying, which usually is the simplest and cheapest method. In the present work, foam-mat drying has been investigated on prickly pear juice and beetroot pulp, compared to conventional drying approaches (spray drying for prickly pear and hot air drying for beetroot). Various proteins (albumin, whey protein, casein, pea protein, soy protein) and polysaccharides (xanthan gum, carboxymethyl cellulose) were tested in a range of concentrations. Buffers (pH 3-6) were also foam-mat dried as a model to evaluate the effect of pH on foaming and drying properties of aqueous systems. Foaming capacity and stability, drying kinetics, betalain retention, powder density and color were evaluated. For aqueous systems and prickly pear juice, proteins alone failed to offer good and stable foams. Xanthan gum addition drastically improved these properties, yielding better stability than carboxymethyl cellulose (0% drainage even at 0.25% concentration). Although albumin exhibited great foaming properties (overrun up to 250%), its drying performance was poor, leading to lower drying constant values. Beetroot on the other hand, proved to have very good foaming properties by itself, even though higher mixing times (15 min) were required. Mixing beetroot into a foam led to a 35% increase in the mass of beetroot that can be dried per hour, compared to unmixed beetroot pulp. Beetroot belatains were preserved at all drying temperatures. Overall, the findings of this study suggest that foam-mat drying has a great potential both for simplifying and for reducing the cost of drying. Search for suitable proteins- polysaccharide systems for foam-mat drying has the challenge that good foaming properties are required, but the blend must not form films with poor water permeability. Hence, future work should aim to find such systems that could be utilized in a great variety of juices and other aqueous systems.

Poster

Effect of pre-treatments on solar drying efficiency and pro-vitamin A content of mango slices

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Mango is one important source of pro-vitamin A, particularly for children and smallholder farmers in the rural areas of Mozambique. Solar drying is used as a technology to contribute to a more sustainable food production in Mozambique, providing added value and a possible additional income to the farmers. This work studies the effect of two different solar drying procedures on the mango pro-vitamin A content.
Two different thicknesses of mango slices were treated in two different ways (blanched and non-blanched) to enhance the retention of β-carotenes, and dried. The solar drying setups were the direct fan (DF) and indirect fan (IF), and the content of β-carotene is determined and compared based on high-performance liquid chromatography (HPLC). The retention of all-trans-β-carotene and the ratio between trans and 13-cis-β-carotene are analyzed. Blanched samples dried in the IF solar setup are expected to have a higher content of all-trans-β-carotene. The evaluation of the efficiency of the solar drying setups, as well as the retention of pro-vitamin A in the samples is reported and discussed.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Characterization of meat cooking kinetics in convective ovens by infrared thermography and image analysis

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Cooking accounts for about 40% of the total energy consumed in the developing world. Thus, understanding cooking kinetics is essential to develop methods with better efficiency and less energy consumption. The aim of this work was to develop a thermal image system for the acquisition of surface temperature of a meat ball during oven-cooking, useful to study and model cooking kinetics.
An infrared window was installed in the door of a professional convection oven to allow a heat camera to capture thermal images of food during cooking. A hemispherical sample (diameter and weight of 12 and 6 cm, respectively) made up of grounded beef meat was used as a model meat product. Two cooking methods were standardized by setting the oven temperature at 180°C with or without oven pre-heating and time at 40 min. For each cooking method, the surface temperature of the meat determined from the thermal images was acquired as a function of time. To assess the degree of browning and the water loss as a function of cooking time, samples were cooked for 10, 15, 20, 25, 30, 40, 45 min and used to measure respectively the color distribution on the external surface and cross-section by using a high-resolution imaging visual analyzer and to measure their weight by a scale. The developed system together with the experimental data acquired formed the basis for the development and validation of a coupled heat and mass transfer mathematical model capable of describing the evolution of beef color during oven cooking.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Analysis of stirred ball milling of food products

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Ball milling is an old, well-known unit operation widely used in the paint and mineral industry. Recently, stirred ball mills are finding increasing application in the chocolate and confectionery industry to reduce the particle size of solids in chocolate, anhydrous pastes and derived products. Such mills have become completely different compared to their old ancestors, and the scientific literature dealing with them is scarce. The few studies that are available are generally limited to the description of the effect of the operating parameters on the product performance, i.e. the particle size distribution or its percentiles, by using empirical models. The aim of this work was to analyse the behaviour of stirred ball mills used in food applications through a stress energy analysis. A case study on the refining of a confectionary product in industrial stirred ball mills is considered.

Poster

Aseptic Processing of Liquid Particulate foods: A bench scale approach

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The achievement of the target sterilization value during aseptic processing of liquid particulate foods is controlled by the residence time in the holding tube and the temperature profile at the center of the critical particle. Establishing of a methodology for accurately calculating the residence time distribution and the temperature profile of moving particles inside a holding tube is challenging. The objective of this work was to develop a bench scale approach of inserting particles in a moving liquid using 2 inch seamless stainless-steel tubes to carry out residence time and heat transfer studies. The by-pass type particle injection apparatus was connected to a transparent acrylic holding tube. Simulated particles were developed in such a way that they were conservative in both flow and thermal properties, such that it will move faster and heat slower than any food particle in the system.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Effects of Drying Methods and Onion Bulb Variety on Physicochemical and Functional Properties of Onion Powder

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Onion (Allium cepa L.) is a rich source of constituents that are beneficial to human health. However, the short shelf life of these vegetables are a major cause of postharvest losses during peak harvesting season. Drying is one of the most convenient technologies for shelf stable food products production. This study is aimed at assessing the effects of three drying methods (industrial oven, electric dryer and sun drying) on physicochemical (moisture content, ash content, pH, titratable acidity, total polyphenol contents) and functional properties (water solubility and particle sizes) of onion powders of two onion varieties (white and violet of galmi). From the results obtained, physicochemical and functional components are affected significantly ($P<0.05$) by drying process but not titratable acidity (to the order of 36 mEq/100g DM). In addition, the moisture content of onion powders were below 13.66±0.115, 14.73±0.115, 14.60±0.305 g/100g WM for industrial oven, electric dryer and sun drying respectively with pH between 3.29 and 5.16. In addition, these powders showed a small particle size (under 400 µm) and high solubility as 93.33±2.3, 72±0.5, 62.66±2.3 g/100 g DM for Electric dryer (ED), Industrial oven (IO) and Sun drying (SD) respectively. Furthermore, polyphenol content was almost different in all the different drying process with values between 721.32 to 962.26 mg GAE/100g DM. Moreover, all properties were varied significantly ($P<0.05$) between white and violet of galmi powders. The preferred drying method and onion variety were industrial oven and violet of galmi. Finally, these results could be a valorization way to promote an industrialization of onion powders.
Keywords: Onion; drying methods; variety vegetable; functional ingredients; total polyphenols.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Development of high-quality table olives using mild pre-treatment methods

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Table olives started as a tradition in the Mediterranean countries, but have, nowadays, become famous to the entire world. More specifically, table olives have become the most popular fermented product worldwide, reaching over 1.000.000 tons every year. Greece is one of the most important producers and exporters. Table olive is a really special food, with specific nutritional value and various benefits for human health. The Greek-style processing involves the direct brining of olives in salt, without any prior chemical pre-treatment for debittering. This process has many advantages regarding low energy consumption; however, the high salt content can affect human health and especially people needing low sodium diets and also the long processing time (8-10 months) required for the fermentation can be a major drawback. The aim of this work was to effectively pretreat black table olives in order to reduce the amount of salt intake and time of fermentation. Osmotic dehydration is a pretreatment method that aims to reduce food humidity by 20-50% with low energy consumption. While water escapes from the food system, solids from the osmotic solution are inserted, and the structure of food changes. Alternative osmotic agents (apple juice, glycerol, glycose and combinations of them) were studied. The osmotic dehydration process was optimized regarding various parameters, such as osmotic concentration, temperature and duration of treatment. Alternative agents led to improved water loss and also managed to succeed salt reduction and reduction of fermentation time. The osmotically dehydrated products were evaluated for their quality characteristics (color, water activity, texture). The final fermented olives were evaluated for their quality and sensory characteristics. The olive products were of superior quality and accepted by consumers.

Acknowledgements
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Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Recent studies on thermal inactivation kinetics

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In this overview, recently developed procedures for the determination of the kinetic parameters of thermal inactivation of heat labile substances are presented. Concentration data vs processing time under isothermal or dynamic temperature conditions are properly analyzed, stochastically or deterministically, to provide estimates of the thermal inactivation kinetic parameters along with their variation. In the classical 2-step procedure, the confidence intervals of the estimates of the rate constants should be taken into account for proper calculation of the variability of the secondary model parameters. Parameter estimation through experiments under dynamic temperature conditions requires more complicated numerical algorithms and cautious selection of the appropriate temperature profiles. The distribution of the thermal inactivation kinetic parameters affects, subsequently, the lethality distribution of a thermal process, and this should be carefully considered in designing thermal processes.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

IMPROVING THE EATING QUALITY OF SPENT BUFFALO (BUBALUS BUBALIS) MEAT USING SOUS-VIDE COOKING

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Sous vide is a French cooking technique of low temperature and longtime cooking performed under vacuum-packed conditions. The current study was conducted to investigate the effect of the sous vide cooking method with different temperatures and time intervals on the eating quality particularly tenderness of two muscles (Bicep femoris (BF) & Semitendinosus (ST)) of spent buffalo (≥ 60-month age) meat. Three steaks from each muscle were cooked at three different time-temperature treatments (T1=55? for 480 minutes, T2= 65? for 300 minutes & C= 95? for 45 minutes), where C was the conventional treatment as control. We analyzed physicochemical parameters including pH, cooking loss, cooking yield, tenderness (WBSF), color (raw & cooked), water activity (aW), total water content (TWC), total collagen content (TCC), heat soluble collagen (HSC) myofibrillar fragmentation index (MFI) and sensory evaluation. The results demonstrated that meat cooked around 55? for 480 minutes showed a reduced WBSF value ($p \leq 0.05$) as compared to the 65? for 300 minutes, while the least value was observed in the control. However, within muscle comparison, semitendinosus (ST) gave more tendered meat as compared to the Bicep femoris (BF). The least cooking losses were observed in low-temperature cooking samples. Hence, more cooking yield ($p \leq 0.05$) was observed in treatment 1 where cooking was done at 55? for 480 minutes as compared to the other two treatments. Similar results were observed for TWC and MFI. In sensory evaluation, semitendinosus steak that was cooked at 55? for 480 minutes was liked by the sensory panelist as compared to the other treatment groups and had more consumer acceptability. A significant difference ($p \leq 0.05$) was also observed in the water activity and meat color between treatments. With muscle variation, cooking loss, myofibrillar fragmentation index, total collagen content (TCC), heat soluble collagen (HSC) & color values were significant ($p \leq 0.05$). Results showed that extended time sous vide cooking along with low temperature helps to reduce toughness and cooking loss while increasing cooking yield and collagen solubility. The key benefit of LTLT sous vide was to provide a better nutritional profile, more uniform cooking, and tendered meat product.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Evolution of the electrical conductivity of pound cake during baking by ohmic heating

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Ohmic heating (OH) is attracting more and more interest due to its many advantages, including high energy conversion efficiency with faster heating kinetics. Having a large number of actual and potential applications, OH seeks to meet the growing demand for new alternative heating technologies in the food industry. In the case of OH, electrical conductivity is a key property as it rules the conversion of electric power to warming power. It is estimated that the ideal electrical conductivity for use in OH is between 0.01 S m-1 and 10 S m-1 (Ramaswamy et al., 2014). In the case of baking, phase changes occurs such as starch gelatinization. The objective of this work was to follow the evolution of the electrical conductivity of a pound cake during baking using OH.
The baking was carried out in a prototype OH cell with an AC voltage of 220V and a frequency of 50 Hz. The degree of starch gelatinization was determined by DSC analysis at selected baking stages and was correlated to the electrical conductivity, which was determined using impedancemetry.
The results of this study showed that there is a negative linear correlation between the electrical conductivity and the degree of starch gelatinization in the center of a cake baked in OH. Increasing the degree of starch gelatinization in the center of the product from 4% at 60°C to about 48% at 76°C leads to a reduction in electrical conductivity from 390 µS/cm to about 89 µS/cm in the same range of temperatures. The reduction of the interstitial space and the availability of water linked to the swelling of the starch granules during gelatinization strongly and negatively impacted the evolution of the electrical conductivity. The increase in the porosity of the cake during baking also reduced the ability of current to flow through the sample.

Conventional processes including refrigeration, drying, thermal, mechanical etc.

Poster

Impacts of the baking heating rate on the water mobility, starch microstructure and mechanical properties of degassed crumb during staling

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Introduction: Different parameters related to the baking process, such as the baking temperature, heating rate (HR), baking duration and temperature beyond the gelatinization temperature affect the texture and staling rate of bread.
Objective: The aim of this study was to assess the impact of the HR from 6 to 40 ?C/min on bread crumb staling in terms of the 1H proton water mobility, starch microstructure, texture, soluble amylose (AM), amylopectin (AP) retrogradation and AM crystallization. In addition to the large HR range tested, there is a novel focus on the amount of AM complexes formed during baking as a function of the HR.
Methods: A degassed breadcrumb baked in a miniaturized baking system was used to ensure better time-temperature control during baking permitting to obtain a large range of HRs (6 ?C/min, 20 ?C/min and 40 ?C/min). The properties of the crumb were evaluated to monitor different parameters related to the progression of staling, including the texture, AP retrogradation and AM crystallization. Water mobility was assessed by low field Proton nuclear magnetic resonance (1H NMR) , and environmental scanning electron microscopy was used to examine the extent of starch granule disruption.
Results: NMR data showed that the evolution of the proton T2 relaxation time decreased with increasing HR during staling. The amount of soluble AM, AP retrogradation degree, AM crystallization degree and crumb firmness tend to increase at higher HR. Microscopic observations demonstrated that most starch granules in crumbs treated at higher HR exhibited strong deformation and disruption.
Conclusion: These results confirmed that the increase in crumb firmness during staling with increasing HR was related to a higher level of starch disruption. This yielded a higher degree of separation between the AM and AP, which resulted in more pronounced water trapping in the starch crystals. The resulting dehydration of the matrix (gluten network, with AM gel surrounding of starch granules) yielded a loss in crumb softness, and crumb baked at higher HR tended to have a firmer texture and faster staling.

Emerging processes & hurdles technologies

Oral

New processing route for strawberry puree using a fermented vegetable juice

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Processed products contribute to a regular fruit and vegetable consumption; however, their processing generally includes intensive thermal treatments and the use of additives, as in the production of strawberry preparation for yoghurts for instance. Indeed, chlorinated washing water as well as heat treatment are applied to reduce the microbial load of yeast and molds commonly spoiling fresh or processed strawberry. An alternative processing was explored in this study, based on the ability of lactic acid bacteria to produce antimicrobial compounds. The aim of this study was to assess the antifungal properties of a vegetable juice, fermented by strains of *Lactobacillus rhamnosus* and *Lactobacillus plantarum* and pasteurized, to stabilize a fresh strawberry puree. Antifungal properties of the juice were first studied in both strawberry puree and a synthetic medium. The synthetic medium, presenting similar physicochemical properties to strawberry, and model strains representative of strawberry spoilage agents (namely *Botrytis cinerea*, *Rhodotorula glutinis* and *Saccharomyces* spp.) were used to limit biological variability observed in the fresh strawberry puree. Compounds with antifungal activities were identified, quantified and their minimal inhibitory concentration (MIC) was determined for each strain using both dilution in broth for yeasts and dilution in solid medium for *B. cinerea*. Incubation temperature was 8°C to simulate chill chain conditions. The use of the fermented juice at 2% on fresh strawberry puree significantly delayed yeast and molds growth by two days. In the synthetic medium, the tested strains exhibited different behaviours with a significant increase in the generation time from 0.5±0.01 d to 0.97±0.3 d and in the lag phase from 0.6±0.1 d to 5.2±0.2 d of *Rhodotorula glutinis* after addition of 10% of juice. Antifungal properties could be attributed to organic acids, especially lactic and acetic acids quantified at 10 and 2 g/L respectively in the fermented juice. Antifungal compounds such as phenyllatic acid, succinic acid and mevalonolactone were also identified. These results are promising and optimisation of the fermented juice towards antifungal compound concentrations close or exceeding the MIC of spoilage agents should improve biopreservation properties, hereby limiting the use of chlorinated washing water and thermal treatments.

Oral

Microbial decontamination using ultra-high irradiance blue light

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Objective: In addition to being pathogenic for the consumer, the presence of microorganisms on the surface of foodstuffs leads to a significant loss of food. The contamination of food occurs at the production site but also during storage when contact with contaminated surfaces. The current solution is the use of chemical molecules causing environmental and toxicological problems. In this context, it is necessary to develop microbial decontamination processes that no longer use these chemical compounds and that ensure the microbiological safety of foodstuffs. Among these processes, photodynamic microbial inactivation based on photo-oxidation, which corresponds to the excitation of exogenous photosensitisers and the production of singlet oxygen, could be used. The objective of this study was to evaluate the efficacy of ultra-high irradiance (UHI) blue light treatments targeting porphyrins, endogenous photosensitisers present in many microorganisms.

Methods: A light reactor capable of emitting blue light (LEDs at 385 and 405 nm) at UHI (901 mW/cm²) has been developed in our laboratory to apply short treatments. The effectiveness of this prototype was evaluated on vegetative and spore-forming forms of food spoilage microorganisms. Cellular damage and inactivation mechanisms were characterised by flow cytometry. Potential applications were investigated for the treatment of food contact surfaces or contaminated fruit.

Results: The application of UHI visible blue light during few minutes was able to inactivate the vegetative and spore-forming forms of the tested microorganisms. However, the treatment times required for inactivation depend on the nature of the microorganisms and their physiological state. It was also observed that 385 nm treatments were more effective than treatments at 405 nm. The lethality of the treatments could be related to the amount of singlet oxygen produced by the treatments. The plasma membrane was identified as one of the main targets whose structure is altered by these treatments. Initial trials on apples contaminated with filamentous fungi have identified scales that are potentially applicable to fruit.

Conclusion: This technology based on the use of certain wavelengths of the visible at UHI could therefore represent an innovative low-cost technology for food applications. Applications concerning the decontamination of pathogenic microorganisms could also be envisaged.

Emerging processes & hurdles technologies

Oral

Biocontrol of mycotoxigenic fungi by Lactic Acid Bacteria and Yeasts in coffee

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Coffee is the most consumed drink all over the world and Ivory Coast is the 3rd biggest African producer (1). Ochratoxin A (OTA) is a nephrotoxic, teratogenic, immunotoxic, and carcinogenic mycotoxin, mainly produced by Aspergillus carbonarius (2). During postharvest, OTA concentration increases due to the contamination with species belonging to the genus Aspergillus sections Circumdati and Nigri. To reduce the presence of OTA, Lactic Acid Bacteria (LAB) and yeasts act as biocontrol agents using direct (adsorption, wall-binding or enzymatic degradation) or indirect (volatiles or metabolites production) mechanisms (3). These mechanisms can also be used to reduce fungal growth. To study the mechanisms that reduce OTA we sampled dry-processed robusta coffee. We isolated, identified, and selected the potentially mycotoxigenic fungal species, and different LAB and yeasts. Confrontation tests of LAB and yeasts against an ochratoxigenic strain of Aspergillus carbonarius were run on solid medium in order to select the biocontrol agents with antimycotoxigenic capacity. Furthermore, the mechanisms of OTA reduction were investigated through tests on liquid medium. The technique of metabarcoding of ITS and 16S regions allowed us to analyse the differences on microbial ecology and its relation to the presence of OTA. The creation of an antimycotoxigenic inoculum, that reduces OTA keeping coffee taste and safety, will have a huge economic impact, since OTA legislative limits in Europe lead to the rejection of 40% of coffee imported from Ivory Coast.

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Emerging processes & hurdles technologies

Oral

Bioconversion of lactose from Greek yoghurt acid whey effluents into prebiotic galactooligosaccharides via a novel hyperthermophilic ?-glucosidase from Thermotoga neapolitana

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The steadily increasing global popularity of Greek strained yoghurt has necessitated alternative approaches of valorization of the acid whey (AW) effluents from the straining process, amounting to twice the volume of the final product. In this context, prebiotic oligosaccharides can be enzymatically synthesized from AW lactose, via conventional and novel glycosyl hydrolases (GHs). Increased thermostability of such hydrolases can be a crucial asset in a combined concentration/oligomerization process.
In this research, the gene encoding a β-glucosidase from the hyperthermophilic bacterium *Thermotoga neapolitana* was cloned and the recombinant enzyme (*Tn*bGal1) was heterologously expressed in *Escherichia coli* and biotechnologically characterized. Enzyme activity and thermostability of *Tn*bGal1 was studied in the temperature and pH ranges of 60-100 °C and 4.0-8.0. Thereafter, *Tn*bGal1 was applied in non-concentrated and concentrated acid whey with lactose concentration of 3.5 to 20 % w/w. The production of galactooligosaccharides (GOS) was monitored over time in relation to lactose concentration and enzyme load, at the optimum reaction conditions. Reaction products were analyzed via High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection and GOS yield in relation to initial lactose content was quantified.
*Tn*bGal1 is a protein of 444 amino acids with a molecular weight of 52 kDa. Optimum catalysis conditions of *Tn*bGal1 were found at 90 °C and pH=5.5, in which enzyme was stable for more than 10 h. Transgalactosylation efficiency of *Tn*bGal1 applied on acid whey was found significant, reaching up to 15.6 % in non-concentrated whey, after 8 h of reaction, using enzyme load of 1 U/mL.
*Tn*bGal1 is a novel, thermostable GH that demonstrated great potential for the oligomerization of AW lactose to produce prebiotic GOS at high temperatures of a combined concentration/oligomerization industrial process. Further research towards optimization of lactose oligomerization will allow efficient, cost effective production of valuable prebiotics in the framework of circular economy.

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Emerging processes & hurdles technologies

Oral

Antimicrobial coating based on essential oils encapsulated in sodium caseinate-guar gum blend to preserve quality of fresh fruits

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Essential oils (EOs) have received much attention as active agent in biopolymer active coating, as promising technology to preserve quality of fresh and minimally processed fruits and vegetables. Sodium caseinate based coatings has been showed to be good carrier of active compounds. Thus, the main aim of the present study was to develop antimicrobial coating based on EOs encapsulated into caseinate/guar gum blend for preservation of fresh and minimally processed strawberries and pears.

Thyme oil (TEO), peppermint oil (PEO), and lemon oil (LEO) were chosen as EOs. The antimicrobial activity of EOs was assessed determining the minimal inhibitory concentration (MIC) against 37 bacterial and fungal isolates from pears and strawberries. EOs at 1,5 % were included in a blend system made of sodium caseinate /guar gum to obtain the active coating. Physical stability, granulometry and rheological properties of the active coatings at 1.5% of OEs has been assessed. For TEO, antimicrobial activity of the active coatings at 0.1%, 0.2% and 1.5% were evaluated by agar well diffusion assay.

TEO showed MIC from 25 to 0.098% (lowest % EO with antimicrobial activity) against all isolates; MIC of PEO and LEO ranged from 50 to 0.098% and from 50 to 12.5% respectively, against 50% of isolates. All the systems showed good physical stability over time. D4,3 values varied from 72 µm for PEO-based blend to ≈ 50 µm for the other two blends. Low uniformity and span values of all the EOs based blends were observed indicating that a quite uniform coarse emulsion was obtained for all. Blends presented high values of zeta potential, from -30 mV for PEO to -54 mV for LEO. Systems showed a shear thinning behavior; LEO-based blend presented the highest viscosity values. 1.5% TEO-based blend confirmed good antimicrobial activity in accordance with MIC results; 0.1% and 0.2% TEO-based blends did not present antimicrobial activity.

All the active blends showed good physical properties for coating application. TEO showed the best antimicrobial activity against natural strawberry and pear microbial populations. TEO and sodium caseinate/guar gum blend at 1.5% can be promising antimicrobial coating for pears and strawberries.

Oral

Altering aromas by applying cold plasma processing

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Aroma is an important sensory property of foods and, alongside flavor and texture (mouthfeel), contributes to the overall sensory experience when eating. While our taste buds can only perceive five stimuli (salt, sweet, sour, bitter, and umami), we can perceive many more odors. As such, most of the eating experience comes from our sense of smell rather than taste. Food processing can alter the odor of several products, and the industry usually relies on adding artificial aromas and essential oils to improve aromas.

Our studies have investigated how green chemistry through the application of cold plasma can help improve the aroma and mitigate off-flavors of several food products. Studies were carried out with orange juice, camu-camu juice, pineapple juice, coffee, lemon essential oil, and citral essential oil, comprising many volatile compounds and chemical classes of compounds. Changes in terpenes, sesquiterpenes, alcohols, aldehydes, esters, pyrazines, furans, and pyrroles were measured. Chemical pathways were proposed and correlated to the changes in aroma and mitigation of off-flavor compounds.

The type of cold plasma technology (glow discharge and dielectric barrier discharge) and the applied operating conditions (voltage, excitation frequency, gas flowrate, and time) significantly influence the kind of reaction imparted to the food aroma. Glow discharge induced more hydrolysis and etching reactions. In contrast, dielectric barrier discharge caused more hydrogenation, isomerization, and hydrolysis at low excitation frequencies and more oxidation and etching at high excitation frequencies.

Green chemistry thought the application of cold plasma could be used to modulate, improve or correct the aroma of several products. Cold plasma showed good modulation capacity of cooling aroma descriptors, such as fenchol, borneol, and camphene, in products containing high terpenoids. Herbal and green descriptors, characterized by several terpenes, alcohols, and aldehydes, also showed high modulation capacity allowing the increase or decrease in the perception of these descriptors in several juices. Nutty and roasted descriptors could be improved in coffee by the changes induced in furans and pyrazines. Thus, cold plasma could be used as a process to change aromas in food products.

Emerging processes & hurdles technologies

Oral

Analysis and Simulation of Transport of Plasma-Activated Mist in Food Safety Applications

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Non-thermal plasma (NTP) is an emerging technology that has the ability to treat foods to extend their shelf lives and reduce microbial loads. The reactive oxygen and nitrogen species (RONS) in air-based plasma are the primary antimicrobial agents; however, current NTP methods do not generate these species in high enough concentrations for NTP to become a commercial technology in the food industry. Plasma-activated mist (PAM) is an emerging application of NTP which contains RONS such ozone, hydrogen peroxide, and peroxynitrite. These RONS are in higher concentrations in PAM than other NTP methods as a result of the high surface to volume ratios that allow effective mass transfer of the RONS. However, in order apply the PAM treatment commercially, it is essential to ensure that the PAM treatment effectively covers the target surface where microbial inactivation is desired. As such, analyses of the fundamental transport mechanisms are necessary in order to understand how PAM is transported in space and how effectively it transfers the antimicrobial charge load to the target surface.

To understand this mechanistically, COMSOL Multiphysics® was used to develop a fluid-flow model to simulate the transport of PAM particles with diameters between 2 µm and 20 µm within a 36 L chamber. This included fluid dynamics, particle-particle-surface electrostatic interactions, and chemical reactions. Computational fluid dynamics and particle-tracing were used to track the flow of PAM microdroplets and evaluate non-uniformity of exposure to PAM.

Numerical simulations demonstrated that PAM microdroplets did not evenly distribute within the model chamber, but rather, separated based on particle size. 20 µm particles do not progress far from the PAM inlet source, whereas 2 µm droplets follow the air flow streamlines and transport more evenly throughout the chamber. In turbulent simulations, less than 50% of PAM microdroplets attached to the bottom surface of the chamber where the microbial inactivation was being evaluated. This uneven distribution will require further research so as to consider all aspects of fluid transport when implementing PAM in a commercial setting.

Oral

Influence of static electric field on the surface tension of selected aqueous solution; interest to stabilize interfaces in foams and emulsions

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Foams are thermodynamically unstable systems and their stabilisation remains a challenge. This project aims at investigating the interest of static-electric-fied (SEF) on the stability of foam systems since SEF is expected to reduce the surface-tension force of some liquids such as water.

Investigations; selected aqueous solutions (water, WPI solution, chickpea liquor) were studied using a modified pendant droplet tensiometer (TECLIS-France). Two parallel electrodes were installed around the pendant droplet and were subjected to a range of DC voltages (0 to 10 kV) corresponding to SEF in the range of 0-250kV/m. The images of the droplet were recorded throughout the experiment. Based on Laplace's equations and thanks to an algorithm that uses the profile of the drop, the surface-tension force was calculated as a function of the applied voltage.The geometry of the drop was deformed under the action of SEF. The drop were elongated with increasing SEF and the deformation was perpendicular to the SEF direction. In agreement with previous publication, the surface-tension decreased proportionally to the rise of the applied SEF. A linear fit was observed and was compared to theoretical model developed by Sato (1997).

Further tests were done using a modified FoamscanTM system (TECLIS-France) equipped with parallel electrodes to the foam column, showing that SEF yielded very stable foams with a reduction of the drainage. The mechanism causing surface-tension reduction was found to be linked to the electric charge located at the interfaces. By reducing the surface tension, gas bubbles or liquid droplets exposed to SEF are likely to break up more easily under shearing conditions (foaming process), offering new horizons in terms of process to obtain “clean labelled” foams or emulsions. In the case of foams, the formation of smaller cells under SEF are expected, which may yield less destabilization phenomena (coalescence, drainage) and a more stable foam during storage.

As a conclusion, the use of SEF in the case of foams or emulsions appears as an innovative method that would allow to stabilize a foam durably, by limiting the use of additives in the product, while reducing the energy consumption during processing.

Oral

Application of pulsed electric fields as an alternative peeling method for tomatoes and kiwifruits

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The industrial transformation of fruits and vegetables typically require a peeling step. However, the current peeling methods (i.e., lye peeling and steam peeling) are not environmentally and energetically sustainable. The two main disadvantages are the disposal of caustic wastewater and the high energy and water consumption. This requires the development of peeling processes that minimize these adverse issues. In the present study, pulsed electric fields (PEF) were applied on tomatoes and kiwifruits in order to investigate an alternative peeling technique. In particular, monopolar exponential shape pulses with an electric field strength of 1.0 kV/cm, frequency of 2 Hz and pulse width of 101 µs were applied. The resulting total energy input was in the range of 0.6 - 5.0 kJ/kg for tomatoes and 1.3 - 12.6 kJ/kg for kiwifruits. The performances of the PEF treatments were compared with two traditional peeling methods: blanching (98 ° C, 60 s) and lye peeling (2 % NaOH, 98 ° C, 45 s). The peeling ability performances were assessed by manual peeling, mechanical peeling, skin resistance to mechanical stress and weight losses. The quality of the peeled products was evaluated by mechanical properties of the pericarp, colour, ascorbic acid content, total carotenoids and polyphenols content and antioxidant activity. The PEF treatment on whole red tomatoes (1.0 kV/cm, 5.0 kJ/kg) and whole kiwifruits (1.0 kV/cm, 12.6 kJ/kg) led up to 43 % and 83 % decrease of force needed for mechanical peel removal, respectively. Compared to blanching and lye peeling, the performance of the PEF treatment resulted in comparable or better peeling ability and in the reduction of pericarp softening and product losses. However, the softening and the weight losses tent to increase by increasing the number of pulses for both the investigated matrices. Additionally, the samples pre-treated with PEF showed a better retention of the polyphenols content and the antioxidant activity compared with blanched and lye peeled samples. This study proved that PEF can be a promising non-thermal and eco-friendly technology to achieve a better peeling of fully ripe tomatoes and kiwifruits, without negatively affecting their final quality.

Emerging processes & hurdles technologies

Oral

Effect of pulsed electric fields on the recovery of docosahexaenoic acid from Crypthecodinium cohnii

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Food industry is in a steadily increasing quest for alternative natural sources of bioactive compounds. Microalgae cultivated on an industrial scale are rich high added value ingredients, such as carotenoids, antioxidants, and polyunsaturated fatty acids. *Crypthecodinium cohnii* is an innovative heterotrophic microalga, containing significant amounts of polyunsaturated fatty acids, mainly docosahexaenoic acid (DHA), of high demand in high nutritional value product formulations. Pulsed electric fields (PEF) cause membrane permeabilization enhancing mass transfer due to exposure of cells to high strength electric fields. The aim of this work was to study the effect of PEF pretreatment of *C. cohnii* cells on the improvement of DHA recovery.

C. cohnii (ATCC 30772) was cultivated in modified ATCC 460 A_2E_6 medium with 27 g/L glucose for 10 days at 27°C. After harvesting *C. cohnii* biomass, PEF treatment (0-15 kV/cm, 100 pulses) was applied on cells suspension. Thereafter, both untreated and PEF-treated *C. cohnii* cells were mixed with the extraction solvent (hexane-isopropanol in different ratios) and left up to 6 h at ambient temperature under constant stirring. The samples were centrifuged and the organic extract was collected and evaporated under vacuum. Lipids extraction yield was determined gravimetrically. Esterification of lipids to fatty acid methyl esters (FAMEs) was caried out for the identification and quantification of extracted omega-3 fatty acids.

The total lipids extraction yield of untreated cells reached 35.8 % w/w. The percentage of DHA in total fatty acids was 56.1%. The results showed that PEF pretreatment (12.6 kV/cm, 100 pulses) significantly increased the extraction yield of total fatty acids up to 53.7% after 1 h of extraction. Additionally, the increased permeabilization of PEF treated cells resulted in acceleration of extraction process by up to 3.5 h. In conclusion, the production of omega-3 fatty acids from microalga C. cohnii, an established industrial process, can be significantly enhanced by PEF as a pretreatment step for the increase extraction yields and overall process efficiency.

Emerging processes & hurdles technologies

Oral

How food processing can engineer the health potential of vegetables

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Brussels sprouts (*Brassica oleracea* var. *gemmifera*) and **leek** (*Allium ampeloprasum* var. *porrum*) are suppliers of multiple health-related compounds, yet understudied in terms of how different steps of the processing chain can be engineered to impact their compound concentrations.
Brussels sprouts store **glucosinolates**, which can be converted by the endogenous plant enzyme myrosinase into health-promoting isothiocyanates. Leeks contain **S-alk(en)yl-L-cysteine sulfoxides**, which can also be converted by the endogenous plant enzyme alliinase into health-promoting organosulfur components. However, these substrates and enzymes are physically separated within and between plant cells. Therefore, processing of vegetables, such as Brussels sprouts and leek, can help to fully exploit their health-potential by enabling interactions between enzymes and substrates.
In this study, the plant tissue structure was first altered by processing to direct these endogenous **enzyme-substrate interactions**. The concentrations of different water-soluble (e.g. glucosinolates, ACSOs and **vitamin C**) and lipid-soluble compounds (e.g. **carotenoids** and **vitamin K1**) were evaluated after processing both vegetables with different techniques. On the one hand, **heating** of intact vegetables prior to mixing resulted in a relatively good preservation of intrinsic compounds attributed to a prompt inactivation of the endogenous enzymes. On the other hand, **mixing** prior to heating largely facilitated enzymatic conversions. Additionally, the impact of a novel, less invasive processing method was studied: **pulsed electric field (PEF)**. This technique is able to preserve the macrostructure while altering the microstructure via electroporation. In other words, it has potential to selectively modify the microstructure while the plant tissue stays intact. It is hypothesized that through the creation of pores in cell membranes, contact between substrate and enzyme could be facilitated. Results confirmed an intermediate conversion of vitamin C and ACSOs after PEF treatment. Generally, interaction effects between health-related compounds were established as higher vitamin C concentrations seemed to have a protective effect on lipid-soluble health-related compounds against oxidation.
Finally, concentration of the health-related compounds were also evaluated through different **storage conditions** (refrigerated storage, and frozen storage above and below glass-transition temperature). It could be concluded that type of processing had a relative larger effect on the retention of health-related compounds compared to storage.

Emerging processes & hurdles technologies

Oral

A new protein source on the rise: Effect of pulsed electric fields and ultrasound on efficient and sustainable protein extraction, yield and techno-functionality from duckweed cultivated under optimized conditions

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In the context of obtaining high-quality protein alternatives, upstream processes are becoming increasingly important with regard to the initial state of raw materials. The focus in this research is on duckweed as a new rich protein source with a complete amino acid profile.
Taking into account the food value chain, optimized cultivation conditions for an optimal protein yield, in greenhouse and indoor vertical farming systems are explored and adapted to the duckweed production process. Moreover, gentle extraction methods are established, for optimal protein extraction assisted by physical processes like pulsed electric fields (PEF) and ultrasonication (US) to observe their implications on cell disruption and protein release from duckweed (L. minor, L. gibba).
For the “green leave protein” RuBisCo, the enzyme that plays an important role in carbon fixation in all green plants, a sustainable extraction process to be designed by three processing steps: pre-extraction, separation of pigments/secondary metabolites and protein isolation.
Pre-extraction of freshly harvested material as well as freeze-dried and subsequently ground duckweed flour is carried out and compared to PEF or US processed samples, which are applied directly on the raw material to break down cell membrane by cell disintegration.
Utilization of these rising technologies PEF and US in our study, has shown a clear improvement for protein release reaching up to 30% by using freshly harvested duckweed. Furthermore, a protein hydrolysis of 95% is achieved by US treatment of a suspension of duckweed flour at an optimized pH of 11, which is ~30% higher than the non-treated duckweed flour. Additionally, US treatment expectedly resulted in smaller particles than 100 µm for 97% of the particles size distribution, which indicates a good degree of cell disruption of plant cells (100-300 µm).
Duckweed protein isolates presented so far a protein yield of 65% and will be adapted based on the predefined optimal pre-extraction procedure assisted by mild heat and ultrafiltration/microfiltration. The isolates will then be analyzed for their techno-functional properties.

Emerging processes & hurdles technologies

Oral

Agar recovery from agarophytes using combined subcritical water and moderate electric fields processing

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Agarophytes are red seaweeds industrially recognized for its agar content, a sulfated polysaccharide present in the cell-wall with technological applications. Subcritical water extraction is based on water's subcritical properties, consisting in the application of high temperature and pressure to increase extraction yields. Ohmic heating results from the application of moderate electric fields (MEF) and both thermal and electrical effects can enhance cell membrane permeabilization. Both processes are valorized due to their eco-friendliness and efficiency being an interesting alternative to the traditional processes.
The objective of this research was to assess the efficiency of subcritical water extraction under application of MEF on the agar recovery from two red seaweeds (*Gracilaria vermiculophylla* and *Gelidium sesquipedale*). The effects of MEF on different properties of the extracted agars were also addressed. Assessed parameters included total extraction and agar yields, structure, monosaccharide composition and molecular weight, gelling ability and rheological behaviour.
Extraction experiments were made using two types of pressurized reactors for each technology (conventional and MEF-assisted), with a solid:solvent ratio of 1:30 for a final volume of 400 mL, without stirring, with a conductivity of 3.5 mS/cm, where distilled water was used as solvent. A frequency of 20 kHz and an electric field ranging from 1-12 V/cm were used only for subcritical water extraction combined with MEF. For *G. sesquipedale*, temperatures and times ranged from 95 (control) to 140 °C and 180 min to 1 s (holding times after reaching the target temperature), respectively, and for *G. vermiculophylla* ranged from 85 (control) to 125 °C and 120 to 1 min, respectively, maintaining the same severity factor.
Combined subcritical water and MEF improved by up to 30 % the agar extraction efficiency, specifically for the 1 s process at 140 °C for *G. sesquipedale*. Gelling ability, rheological behaviour, structure, 3,6-AG content and molecular weight distribution of the agars extracted were not impaired by different treatments and extraction technologies.
Therefore, the combined use of subcritical water and MEF as a novel and innovative extraction technology may be an excellent alternative, improving extraction performances (with reduced processing time and increased extraction yield) to recover agar from agarophytes.

Emerging processes & hurdles technologies

Oral

Accelerated Inactivation of Bacterial Spores by Interaction of Electric Fields with Key Spore Components

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Prior work shows that the electrical components of ohmic heating (OH) cause accelerated inactivation of bacterial spores. In this work we explored the effects of electric field strength on the inactivation of *Clostridium sporogenes* PA3679 (a surrogate of *Clostridium botulinum*), and *Bacillus subtilis* PS533 (wild-type) & PS578 (lacking Small Acid-Soluble Proteins: SASP). Matching the temperature history is crucial for comparing the thermal and ohmic treatment: we used a specialized apparatus that allowed us to achieve that goal. In this study we allowed the temperature to rise linearly by applying a constant electric field, and once the samples reached the set temperature, they were immediately cooled i.e., with zero holding time. We conducted experiments with three field strengths (30, 40, and 50 V/cm), and three final temperature settings (95, 105, and 115oC for *B. subtilis*, and 110, 120, and 130oC for *C. sporogenes*) respectively. Our results show that field strength had a strong effect on the inactivation of both spores, for instance the reduction in *C. sporogenes* counts increased from 1.71±0.06 CFU/ml for 30 V/cm to 3.9±0.52 CFU/ml for 50 V/cm at 130oC. Similarly, for *B. subtilis*, the inactivation increased from 1.72±0.04 to 4.94±0.28 CFU/ml at 115oC. We compared the inactivation data of ohmic with that of conventional heating by matching the temperature histories and we found a significant difference between ohmic and conventional. Furthermore, results of tests with spores of *B. subtilis* that lacked SASPs suggest that SASPs are one of the targets of the electric field. These findings add to our understanding of the nonthermal effects of OH and highlight the potential of OH to be used as an efficient way to kill spores without significantly affecting product quality.

Oral

Tailored ohmic heating concepts for the targeted processing of vegetables

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Ohmic heating (OH) is an innovative heating technology which enables the optimization of conventional thermal processes with regard to resource efficiency, process efficacy and quality retention of the product. Through volumetric heating, OH provides the potential to reduce processing times and energy consumption which contributes to sustainable energy management in times of the current energy crisis. However, product and process parameters influence the efficiency and homogeneity of OH processes. Therefore, this study aimed to optimize OH treatments to create targeted thermal processes for inhomogeneous raw materials such as vegetables. For this purpose, thermal and electrical pre-treatments were used to disintegrate the vegetable cells to minimize non-uniformities in the electrical conductivity of the tissue which influence the heating homogeneity. The changes in local conductivity were assessed before and after different pre-treatments and during OH. Additionally, the influence of different pulse repetition frequencies (12 kHz and 300 kHz) was assessed to accelerate the heating rate and uniformity. The effects were analyzed by thermal imaging and temperature kinetics using product-specific cooking values. The effects on the cooking behavior were evaluated by cell disintegration index, cooking loss, dry matter, color and texture in different product parts. OH processes were compared with conventional boiling in water. The results of the study showed distinct potential for the use of pre-treatments for a rapid and more homogeneous OH of vegetables (cooking time reduction of up to 36 %) and accelerated heating rates due to cell disintegration of up to 90 % of the plant tissue. The use of a higher pulse repetition frequency (300 kHz) led to increased electrical conductivities (up to 2 mS/ cm higher) in the vegetable tissue which resulted in improved heating uniformity compared to 12 kHz. The use of tailored process conditions with additional pre-treatment showed enhanced product properties like increased color retention (up to 90 %) and texture uniformity of the cooked vegetables. The results provide a better understanding of the influence of pre-treatments and specific process parameters on product properties during and after OH which enables process optimization and the implementation of targeted processing concepts for OH with lower energy requirements.

Oral

New Microwave pasteurization of ready meals

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The pasteurization by microwaves is a fast process which prolongs the shelf life of food while minimizing the damage of quality compared to the conventional sources of heat which transfer the energy of the outside towards the interior. The microwave treatment heats the product directly by absorption of electromagnetic energy by the food components. The transmission of energy is faster and therefore preserves the quality of the food.
Sairem has developed a patented process to allow microwave heating of the product while maintaining the sealing properties of the system, without rupturing the plastic film. Also, as this process is waterless, we can process cardboard trays, fiber trays... (more environmentally friendly). This process is also 100% electric and is therefore in line with the current trend to electrify processes.
The development of this technology is carried out in partnership with the CTCPA of Avignon, which has the first pilot equipment installed in their technology hall. (https://www.youtube.com/watch?v=oKEdKY8kef4). It is an innovative technology that is no longer at the laboratory stage, this pilot allows us to make tests with an important scale. Several tests and discussions are in progress with potential customers to set up an industrial production line.
First research studies have shown that it was possible to pasteurize different recipes with pasteurization values of about 1500 - 2000 min while preserving the integrity of the packaging. 3 demonstration recipes have been realized:
- Mashed potato grandmother style
- Potato sauce with sunny vegetables
- Salmon, green beans and sweet potato puree

For all the recipes we have a shelf life of more than 25 days (microbiotic analysis following the standards of the sector and study conducted by the CTCPA)
The processing times are short which allows to keep the organoleptic and nutritional properties of the product, this has been demonstrated by the realization of sensory panel by Innovaliance (consumer test on 100 people with rating of their preference on different attribute)
This research work is still in progress to find ways of optimization and also to demonstrate the energetic efficiency of the system (measurement of consumption during the realization)

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Emerging processes & hurdles technologies

Oral

A minimal processing approach: unravelling the synergistic effect of combining low & high frequency electric fields to ensure microbial safety in liquid foods

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Radio frequency (RF) is a novel alternative to conventional thermal treatment to ensure microbial safety in liquid foods. The frequency plays an important role in the mechanism of microbial inactivation by RF, with low frequencies (LF) occupying the range below 100 kHz and providing a non-thermal effect whereas high frequencies (HF), within the MHz range, mainly causing thermal inactivation.
Minimal processing approaches exploit the additive or synergistic effects of combining different treatments at mild or moderate conditions to ensure microbial safety. The synergistic effect, which is achieved by targeting multiple sites within the microbial cells, enhances the inactivation level, reduces the required energy input, and minimizes the impact on nutritional and quality attributes. This is of paramount importance as consumer demands in recent years have favored fresh-like and natural products.
In this study, we investigated the synergistic effect of combining LF and HF treatments on *Escherichia coli (E.coli)* inactivation in liquid foods. We demonstrated that synergism can be achieved in the liquid food model when LF at a minimum of 10 kV cm^{-1} and 40 °C was combined with HF at a minimum of 1.9 kV cm^{-1} and 60 °C. The synergism yielded a minimum 5 log reduction in the *E.coli* population, which fulfilled the requirements set by food authorities. Furthermore, the optimal conditions were applied to actual liquid foods demonstrating synergy. Finally, electron microscopy techniques exhibited that LF alone disrupted the ultrastructure of *E.coli* cell wall whilst HF additionally degraded cytoplasmic components. The HF treatment provided an ultrashort thermal effect as the treatment time was within the ms range. The sequential combination of LF and HF treatments caused greater ultrastructural damage to *E.coli* as designated by detected puncture and rupture of the cell walls as well as leakage of cytoplasmic content.

Emerging processes & hurdles technologies

Oral

Electric and magnetic field-based supercooling technology to ensure the freshness of yellowfin tuna (Thunnus albacares)

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Fish is one of the most perishable aquatic foods since it is easily spoiled and oxidized. Freezing is commonly used to extend shelf life to minimize pathogens and enzymatic activity; however, it accompanies quality degradation caused by ice crystallization. Supercooling is defined as the process of cooling a food product below its freezing temperature without ice crystal formation. Water in food is susceptible to be magnetized by a magnetic field (MF) since it is a diamagnetic material. In addition, water consists of dipole molecules, indicating that water molecules tend to realign and re-orientate under an applied electric field (EF). Therefore, electric and magnetic fields can directly act upon water in foods to prevent ice nucleation and promote supercooling during the freezing process.

Various strengths of EF and MF were applied to supercool sashimi-grade tuna fillets (~210 g) at -4 degC for 10 days, and quality changes, such as drip loss, color, microbial analysis, texture, and lipid oxidation, were examined and compared with samples subject to conventional refrigeration and freezing conditions.

The quality factors of EF and MF-treated tuna samples were compared with fresh, refrigerated, and frozen samples after 1, 4, 7, and 10 days of storage. The total volatile basic nitrogen (TVB-N) value of refrigerated tuna samples was significantly higher than frozen and supercooled tuna samples after 1, 4, 7, and 10-day of storage ($P < 0.05$). Specifically, the delta TVB-N value of the refrigerated tuna sample was 2.6, 5.4, 12.2, and 15.6 mg N/100g after 1, 4, 7, and 10 days, respectively. The aerobic count plate (ACP) value of the supercooled tuna sample was not significantly different during the storage of 7 days. Tuna samples preserved in the supercooled state showed significantly lower values in the drip loss (0.8%), compared to the refrigerated (2.1%) and frozen samples (8.2%). In addition, the color changes and texture evidenced that the supercooled state reduced quality degradation. Supercooling preservation using the combined EF and MF technology allowed the tuna fillets to improve their shelf-life while maintaining unfrozen and fresh at subzero temperatures.

Oral

Changes in tissue structure and electrical properties of apple by vacuum impregnation treatment

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Electrical impedance spectroscopy has been used as a method for evaluating the cell membrane structure of fruits and vegetables. However, in addition to cell membrane damage, tissue structure changes due to tissue shrinkage and water influx are caused by various processing operations, which may affect electrical properties. In this study, impedance and porosity were measured on apples treated by vacuum impregnation to clarify the relationships between tissue structure and electrical properties. Apple samples which cut into cylindrical pieces with a diameter of 5.5 mm and a length of 20 mm were prepared and subjected to vacuum impregnation treatment. Vacuum impregnation was performed by immersion in distilled water at 100, 200, 400, 600, and 800 MPa for 1 minute. For impedance measurements, needle electrodes were inserted into each sample, and the resistance and reactance were measured at 100 points between 50 Hz and 5 MHz. Then, equivalent circuit analysis using the CPE model was performed to quantitatively evaluate the electrical characteristics, and the intracellular resistance, extracellular resistance, and cell membrane capacitance were determined. The porosity was calculated from X-ray micro-CT images using the software CTAn. In the equivalent circuit analysis, the CPE model was well fitted to the measured values. The intracellular resistance did not change significantly with impregnation pressure. On the other hand, the extracellular resistance became smaller as the impregnation pressure was lowered, suggesting that the conductive area increased due to the inflow of water into the voids. The vacuum impregnation treatment also induced increase in the cell membrane capacitance, thus it was assumed that the treatment caused tissue shrinkage and cell membrane density between electrodes increased. Porosity decreased with decreasing impregnation pressure. A strong negative correlation was observed between the capacitance and porosity (R=-0.929). In apples, porosity was found to contribute to the impedance parameter, and impedance measurement could be used to predict porosity.

Emerging processes & hurdles technologies

Oral

Ball milling: innovative and sustainable technology for the development of innovative and high-performing food ingredients

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Global compelling need for a more sustainable economic system fueled the food sector, to develop and promote the application of innovative and more environmentally friendly technologies.
Ball-milling, initially developed by the pharmaceutical sector, nowadays finds application in several fields mainly for micro-powders production. This technology is based on the effects of high energy mechanical forces (e.g. attrition, shear, and impact) induced by the collision of balls within a jar under high rotational speed. Researches showed that it may induce physical, structural modifications and state transitions in biopolimers and solutes in dry state, causing changes of their chemical and physical properties and technological performances. Limited are the studies on this technology in food processing and ingredients development and its full potential still remain unraveled.
This presentation will review the results of some applications of the ball-milling technology in modulating techno-functional properties of food molecules and the development of innovative encapsulated ingredients.
Ball-milling applied to small saccharides (trehalose), in presence of limonene (co-milling), allowed the development of amorphous powdered encapsulates. The high-intensity mechanical stresses cause stepwise transition from the crystal to an amorphous state of the saccharide, along with the formation of a micro-dispersion of limonene as to a high-performing, stable, glassy encapsulated powder with a high retention ability of the volatile compound. Similar encapsulation approaches have been applied also for valorization of olive oil processing by-products. Co-milling of maltodextrin alone or maltodextrin-trehalose mixtures (90/10; w/w) combined with an olive leaves extract resulted in an encapsulation efficiency higher than 90% after 1 h-treatment with an effect related to processing time and carrier composition.
Modulation of technological functionalities of native corn starch have been achived by short-time ball-milling treatments. At increasing treatment time, milled starch showed significant changes of the semicrystalline structure of the granules and physico-chemical properties resulting in a mechanic-induced gelatinization, increased cold water solubility, oil and water holding capacity. Moreover, aqueous milled-starch dispersions subjected to heat-treatments showed interesting pasting and rheological properties to be exploited for new formulated foods.
Nowadays, ball-milling represents a "green" technology to obtain, in dry-state, innovative and sustainable ingredients.

Oral

New engineering solutions for pathogen control in low moisture foods

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The outbreaks associated with milk powder, crackers, peanut butters, spices, and chocolates over the past decade have created emerging concern over safety of low moisture foods. But the food industry experienced difficulty in developing effective pasteurization for those products. Experimental evidents have shown when dehyrated bacterial bathogens, such as Salmonella, are extremely tolurant to thermal treatments, the thermal processing conditions designed for high and intermediate moisture foods are not more effective for low moisture foods. These bacterial bathogens can also survive for months or even years in most low moisture foods. There is a need for foundmanal understanding about the influence of key factors on thermal resistance of bacterial pathogens in order to design and validate thermal treatements for low moisture foods.

This presentation provides a summary of recent results from our research on thermal inactivation of Salmonella and a surrogate, E. faecium, in low moisture foods. Our research consisted of three major components: 1) determining water activity (aw) of different food matrices over a range of temperatures to establish relationships between product moisture content, aw, and temperature; 2) determining thermal resistance (D values) of Salmonella and E. faecium in low moisture foods as functions of temperature and aw; 3) using the above knowledge to develop and validate thermal processing based on radio frequency heating and controlled high relative humidity.

Our studies show that aw of food generally increases with temperature. But aw of oil decreases sharply with temperature. aw of food matrices at treatment temperatures (not measured at room temperature) is a determinant factor on thermal resistance (D values) of bacterial pathogens. At a fixed temperature, D value for Salmonella and E. faecium in difference matrices increased exponentially, by up to 100 fold, with reduction of aw measured at treatment temperature from 0.7 to 0.2. The above results explain the difficulty in thermal activation of bacteria pathogens in foods having low aw at elevated temperatures and in oil-rich products. Our studies demonstrated that relative humidity at high temperatures can be used as a control parameter in designing thermal treatment operations for pathogen control in low moisture foods.

Oral

Novel foaming technology applying gas hydrate slurries and its application for foods and upcycled biomass waste streams

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A novel technology for foaming viscous food matrices is introduced. The process involves crystalline gas hydrate dispersions as a functional foaming ingredient. Gas hydrates are crystalline inclusion structures consisting of hydrogen-bonded, three-dimensional cages from water molecules, entrapping gas molecules. Main challenges of using gas hydrates as foaming agent are (i) their elevated pressure narrow phase stability domains and (ii) their crystal connectivity favoring aggregate formation (e.g. in pipes/nozzles). Foaming with gas hydrates involves three steps: (i) forming a gas hydrate slurry (GHS), (ii) dosing the GHS into an un-foamed pressurized product stream and (iii) inducing foam formation by expanding the gas hydrate/product mix. Gas hydrate slurries were characterized in terms of gas storage capacity, rheology and expansion behavior. A thermodynamic model for ternary systems was developed for quantitative analysis of the gas distribution in the multiphase system. Homogeneously flowable CO_2 hydrate slurries with an average of 14 vol% hydrate solids and foaming capacities of up to the ca. 160-fold volume of the hydrate crystal volume were successfully processed and applied for foaming of food systems.
The upscaled (pilot scale) technology consists of (i) an in-house (ETH) built gas hydrate formation reactor designed for up to 450 bar operational pressure and (ii) a high-pressure mixing homogenizing unit such as an extruder and/or (iii) a surface-scraped heat exchanger. The pressure range covers the stability region of most gas hydrate formers. We focused on the formation of single-gas CO_2(formation pressure 15-55 bar), mixed gas CO_2/N_2 (formation pressure 15-450 bar) and single gas N_2 (formation pressure 130-450 bar) hydrate crystalline slurries.
The new technology is expected to offer great potential in facilitating micro-foam formation, in most highly viscous matrix fluid systems since the gas hydrate crystals can be used as a "foaming ingredient" (propellant) which can be well dispersed before their gas load release is activated by pressure and/or temperature adaptation. First steps have also been taken in applying the novel gas hydrate-based foaming technology for the valorization of highly abundant cereal and fruit biomass waste streams into foamed biomaterials for fast disposables such as protective packaging and biodegradable foams for plant substrates.

Oral

Analysis and improvement of the cashew nut shelling process

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Keywords: food engineering, cashew nut shelling process, analysis, improvement,

Cashew nut processing is a complex, poorly optimised and energy-intensive process. In Senegal, it is still largely carried out on an artisanal scale and more recently by small and medium-sized enterprises. The process starts with a long and tedious operation of shelling the nuts, which has a strong influence on the proportion of whole kernels obtained, and therefore the value of the product. Indeed, the yields of whole kernels after shelling observed are on average 50% and can at best reach 65% (Azam-Ali and Judge, 2001). Three pre-treatments (water immersion, steaming and air drying) are usually applied alone or in combination to facilitate shelling. Therefore, the objective of this study was to investigate the impact of these pre-treatments. For this purpose, an experimental study was conducted to identify the importance of each step and the control factors of the process. The shelling quality was evaluated by assessing the hardness of the shell (breaking strength) and quantifying the yield of whole kernels as well as the speed of shelling.
The study shows that the 3 pre-treatment unit operations when combined, weaken the nut and facilitate shelling. The control factors identified for these pre-treatments identified and their range of variation are the moisture content of the nuts from water immersion (7.68 - 20 % d.b.), the duration of steam treatment at 100°C (30 - 60 min) and the temperature of the drying operation. A factorial design was used and showed that the water content related to immersion had the greatest impact on hulling quality, followed by steaming time and, to a lesser extent, drying temperature (30 - 60 °C). A water content of 20% (d.b.), a steaming time of 60 min and a drying time of 60°C for 9 hours weaken the nut at best (breaking force of 800 newtons) and allow to reach a whole kernel yield of 90% while maintaining a shelling rate of about 4 whole kernels/min, i.e. twice as high as what is observed in real production. Further studies are needed to better understand the mechanisms of nut embrittlement and optimize the whole process.

Emerging processes & hurdles technologies

Oral

Hyperbaric inactivation – a nonthermal approach to inactivate Bacillus subtilis endospores at room temperature

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Introduction:
Hyperbaric inactivation (HI) is a nonthermal, low-pressure-based processing methodology that makes use of moderate hydrostatic pressures (up to 250 MPa) for long dwell times (hours to days) to achieve pasteurization standards in heat and pressure-sensible foods. Recently, this methodology has shown great potential to not only inactivate vegetative microorganisms but also bacterial spores, which are highly resistant either to conventional thermal pasteurization or high-pressure processing, being required temperatures above 100 ºC for several minutes to inactivate them. Considering the importance of bacterial spores for both food safety and shelf-life, it is of upmost importance to evaluate the feasibility of this methodology for endospore inactivation in a range of pH-values important for food safety.

Objectives:
The present work aimed to evaluate the potential of HI to destroy Bacillus subtilis endospores, and the dependence of pH and nutrient-availability for endospore inactivation, and the inherent kinetic parameters. To do so, B. subtilis endospores were inoculated in nutrient-free McIlvaine buffer and Brain-heart infusion broth at three different pH levels (4.50, 6.00 and 7.50) and kept under hyperbaric inactivation (150, 200 and 250 MPa) up to 7 days at uncontrolled room temperature (18-25 ºC).

Results:
The results demonstrated a clear dependence of nutrient-availability and pH upon endospore inactivation under HI conditions, which allowed to fit both linear and non-linear (Weibull, Log-logistic and Biphasic) kinetic models frequently used to describe endospore inactivation patterns. Lower pH values hindered endospore inactivation at 150 MPa, even in the presence of nutrients, which could be surpassed at and above 200 MPa. Additionally, the presence of nutrients accelerated endospore inactivation, which ultimately impacted the inactivation kinetic parameters. Curiously, a pressure increase from 200 to 250 MPa did not accelerate endospore inactivation at both pH 6.00 and 7.50.
Moreover, phase-contrast microscopy images revealed that the endospores were inactivated without reaching the vegetative state, which is an important outcome for food safety.

Conclusions:
There results show that HI can be an interesting approach for the inactivation of bacterial spores at room temperature, without applying any heat, which could be particularly interesting for heat-sensible foods and other matrices.

Oral

Stabilization of functional goat milk by using high pressure processing

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Fish oil are the richest sources of long chain polyunsaturated fatty acids especially omega 3 PUFA. Fortification fish oil into various foods is an innovative choice of elevating the intake of omega-3 fatty acids without changes in eating habits. However, adding lipids such as omega 3 PUFA into food products gives rise to major formulation challenges. Oxidation of fatty acids is a major cause of food deterioration which effects on the properties of food such as aroma, flavor, color and shelf life. One way of reducing fatty acid oxidation of through lipid encapsulation. In addition, there is more incidents of children who allergy to protein in cow milk, thus goat milk is an alternative source. In this paper, functional goat milk was developed by incorporating fish oil emulsion and stabilized into complex carbohydrate system. The product was then processed under high pressure processing (HPP). The study selected goat milk that contained 0.04% Konjac glucomannan solution at pH 9-10 were mixed with 5% fish oil and homogenized. After that, mixtures were subjected to HPP at 400, 500 and 600 MPa. Stability of emulsion including particle size, PDI, zeta-potential, oxidative stability and microbial population count were determined. The results in this section were found that, increased pressure resulting in decreased particle size and PDI. However, pressure had no effect on zeta potential values. HPP improved emulsion stability compared to control from 10 days to 14 days. As for the oxidative stability, which was reported as hydroperoxides values (PV) and thiobarbituric acid values (TBARS), it was found that HPP led to increases in the PV and TBAR values of 5% fish oil emulsion made with 0.04 % KGM at pH 9 and 10, indicating that oxidation of the emulsions was promoted in the high-pressure conditions. For number of microorganisms, which the results showed that the pressure reduced the microbial load. The maximum reduction of microorganisms occurred at a pressure of 600 MPa.

Oral

Manufacturing programmable liquid-filled channels in 3D printed ink-gel structures to deliver personalized doses of micro-nutrients.

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Recent advances in 3D Food Printing have been shown the opportunities to renew the human food interactions introducing innovative possibilities in the field of digital food manufacturing, on-demand production, new sensory perceptions, and customized food products. With the improvement of engineering aspects such us the increased printing speed and multi-materials deposition, the goal of designing and develop 3D printed food thought to fulfill the nutritional requirements of each people, is receiving large attention from researchers and private companies for the future of the personalized food industry. We used a 3D digital approach to design and realize 3D printed structures to deliver personalized doses of micronutrients. First, the specific requirements of some micronutrients, such as iron, calcium, zinc, etc., have been defined for different consumer's groups. Second, programmable void channels of different dimensions, shapes and positions have been designed and built into edible 3D printed ink-gel structures during the printing process. Finally, specific doses of minerals such as iron, calcium, etc., have been incorporated in the gels, by filling the generated voids-channels with solutions of such micronutrients at different concentrations. The accuracy of replicating the digital models has been studied by analyzing 2D/3D micro-CT images of the printed structures. Also, the 3D printed foods have been described for their mechanical properties and the acceptance considering the effects of the spatial distributions of the liquid-filled channels in the 3D space on the sensory perception. The utilized strategy proved the potential of using 3D Food Printing to create on-demand food structures based on desired shape, dimensions, sensory properties and personalized quantity of micronutrients. Further experiments will expand this strategy to other nutrients and for different printed food materials (i.e. cereal-based structures).

Oral

Novel Synchronous Multi-Scale 3D-printing of foods for tailored sugar-reduced sweetness perception

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Introducing additive manufacturing (AM) techniques into the food value chain is challenging due to low margins typically associated with food products compared to medical or mechanical engineering products. Furthermore, the complex rheology of food requires careful design of extruding and/or dispensing units posing additional hurdles for AM applications. Here, we present a novel AM approach capable of producing complex 3D food structures at elevated production rates and with added functionality perspective.

As a food category of elevated interest for significant calorie density reduction by novel AM means, we chose multiphase chocolate confectionery products. The complex 3D structure was broken down into three main length scales denoted as macro-, meso- and micro scale. The macro scale product elements acting as scaffold for the meso-scale elements are manufactured by twin-screw cold extrusion applying a macro-scale printing die (cm-range). Two six-axis robots equipped with a single screw meso-scale (mm-range) extruder system and an electromagnetically triggered single/multi jetting micro-scale (100 micrometer scale) nozzle dose and shape the meso- and micro- scale product elements and connect them synchronously to the macro scale printed scaffold element.

With the introduced SYnchronous MUltiScale (SYMUS) 3D-printing technology we demonstrate how to rapidly manufacture a multiphase chocolate confectionery product composed of different phases from print materials with non-Newtonian and highly temperature dependent flow behavior. Moreover, we show how to apply this novel AM-based production technology for the processing of high-quality chocolate confectionery products with significantly lowered calorie density by sugar reduction while still providing a well perceived sweetness sensation. For the latter aspect approval, we applied not only conventional sensory evaluation but in addition neuroscience-based methodologies (EEG, fMRI) enabling complementary brain response information access on the sweetness perception kinetics dependency from the spatial arrangement of printed “sweet product domains”.

Such spatially resolved texture and aroma/flavor functionality of the presented chocolate products indicate the powerful toolbox for the generation of new organoleptic properties while fulfilling requirements for nutritional and sustainability benefits thus generating added value across the entire food value chain using the introduced Synchronous Multiscale 3D-Printing based Additive Manufacturing technique.

Oral

Evaluation of potato starch gelling ingredients (native and modified by dry heating) and post-processing in the texture of 3D printed foods

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3D printing technology has recently been widely applied to fabricate food with complex shapes and textures. In addition, starch has shown the potential to prepare hydrogel inks for 3D-printed food production. This source offers advantages such as being available worldwide, relatively cheap, and having gelling properties. However, starch-based hydrogels present processing difficulties, mainly associated with their rheological properties. Some starch modification methods have been performed to overcome these difficulties, for example, the dry heating treatment (DHT), a simple, safe, physical, and "green" treatment. In addition, post-processing can strongly influence the dimensional accuracy and texture of the printed food. In this context, this work aimed to evaluate the performance of hydrogels (10% w/w) based on native or dry heating modified potato starch (4 h, 130 ºC) and the effect of post-processing on the performance of 3D printed food. The 3D printer (3D BioedPrinterV4-BioEdTech, Brazil) and the parameters used were: 15% filling percentage, ten layers, 100% extrusion flow rate, 10 mm/s of printing speed, and a cylinder with 20 mm of diameter. The post-processing evaluated were oven drying (45 ºC and 15% RH) and freeze-drying (-20 ºC). The printed food's weight, dimensions, and mechanical properties (TPA tests, TA Instrument TA.TX Plus, UK) were evaluated. The hydrogels based on modified starches showed lower hardness and higher adhesiveness than the native ones. Also, modified starch resulted in printed food with higher reproducibility. In addition, freeze-drying was able to preserve better the accuracy of printed food and to obtain 3D-printed food softer than that dried in the oven. Finally, this study was fundamental to showing how different gelling agents from the same starch source and how post-processing can affect the quality of printed food, including from a visual aspect to textural properties.

Oral

Impact of macronutrient composition on 3D printability of pea-based food formulations

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The emerging technology of 3D food printing is promising for production of personalized foods. Personalized foods are ideal for individual dietary requirements of a consumer, thereby helping to sustain a healthier diet. However, especially changing the macronutrient composition of foods, i.e. the amount of carbohydrates, proteins and fat, is known to strongly affect the printability—extrudability and buildability—of food formulations. In addition, the amount of added water used for preparing formulations plays an important role. The influences of macronutrients and water are complex and have not been studied systematically before. Therefore, the aim of this study was to investigate the influence of macronutrient composition on printability and rheology using a quantitative experimental design approach. For this, a pea-based model food formulation varying in fibre, starch, and protein content was evaluated in terms of printability namely: (a) extrudability and (b) buildability which was further linked with their rheological properties. A systematic study was conducted by varying one macronutrient at a time. Water content was adapted based on water holding capacity of the various ingredients. From the results, it was found that water holding capacity is a good starting point for systematic formulation of printed foods with various macronutrient composition. Subsequently, it was observed that fibre and protein had a stronger effect on extrusion force and flow point than starch, which may be explained by the microstructure of the formulations. Compositions containing 30-80% fibre, 10-50% protein, and 0-60% starch on dry basis were identified as the ranges within which stable printed samples could be obtained. The knowledge obtained from this research provides a window of operation for successful 3D printing of pea-based formulations and the approach may be used for other printable food formulations as well.

Keywords: Macronutrient composition, personalized foods, 3D food printing

Emerging processes & hurdles technologies

Oral

Investigation of Pound Cake Baking in the Case of Ohmic Heating for an application in 3D printing

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Considering food material composition of most bakery products such as the presence of fat, 3D printed foods of such matrices are mostly not able to retain their structure/shape after the baking step, which is necessary to cook/solidify the product. Ohmic heating (OH) offers new limits to the food industry due to its volumetric principle of heating with minimum temperature gradient. It also comes several advantages such as, high-energy conversion efficiency, and possible high heating rate. The insertion of this technology in the printing head of 3D printer would yield pre-cooking with high throughput printing. The research concerning the application of OH in the baking industry is scarce and the mechanisms of cake making using OH are poorly understood. The objective of this study is to adjust a pound cake recipe and investigate the baking process by ohmic heating, using conventional oven baking as a reference.

Experiments were first carried out in the batch process, where, different OH process parameters (heating rate, power input and holding time) were tested and their effect on the physico-chemical properties of batter and cakes (specific volume, porosity, starch gelatinization, texture) were analysed. Alongside, the effect of leavening acid type with different levels of baking powder (BP) on batter and cake properties were also studied. Results indicated very clear significant differences in the appearance cakes between the two methods of baking, in which OH cakes were crustless. Time of baking was reduced by 50 - 60% when OH was used, and as heating rate increased from 3.2°C/min to 6.4°C/min, crumb firmness of OH cakes were significantly reduced. On the other hand, increasing BP amount significantly increased batter specific volume and porosity, but dropped as BP level approached maximum (4.52%).

Overall, study helped to explore the process parameters of cake baking by OH and highlights the need to identify the optimum amount of BP to attain the desired product qualities. Perspectives concern the application of this technology for continuous baking of cereal matrices, aiming at its implementation in 3D printing.

Oral

Rheological and 3D printing behavior of pea and soy protein pastes

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There has been an increasing demand for the utilization of plant-based proteins as substitute for those of animal-origin in food formulations. Furthermore, manufacture of food products by three-dimensional (3D) printing is receiving increased attention as a way to produce foods with wide customization possibilities in terms of shape, flavor, texture, color, and nutritional value.
The aim of this study was to gain a better understanding of the importance of the rheological behavior of plant-protein food inks on their 'printability' following extrusion 3D printing. The viscoelastic properties of pea and soy protein pastes with concentrations ranging from 10-21%w/w were correlated with their 'printability'. The rheological parameters G?, tanδ and σy were affected by the protein concentration, and a different viscoelastic behavior was observed for PPI and SPI pastes. At low protein concentrations (10-16%w/w) SPI is more elastic than PPI, whereas at higher protein concentrations their behavior was similar. For both protein systems the tanδ, was only slightly affected by the protein concentration, while both the G? and σy increased exponentially as a function of the protein concentration. No self-supporting structures could be printed for pastes with protein concentrations <15%w/w, and for concentrations >19%w/w imperfections and inhomogeneity in the surface structure are observed. In the protein range of 15-17%w/w, SPI formed more stable 3D printed objects compared to PPI. SPI shows a more elastic structure that increases stability against collapse during the 3D printing. At higher protein concentrations (>17%w/w) for PPI, the increase of G?, σy and K counteracted the importance of n and tanδ, resulting in self-supporting 3D printed products becoming more similar to SPI. Having quantified both rheological and printing properties, multicomponent analysis was performed to identify correlations. Among the different rheological parameters analyzed a modest correlation to printability was found with the G?. This work provides a better understanding of the importance of rheology of plant-protein food inks to printability by attempting to establish printing predictors, which is important for the development of new inks for 3D printed foods.

Emerging processes & hurdles technologies

Oral

4D printing of shape-morphing foods: Control of stimulus-driven deformations through protein-starch thermal transitions

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Since its adoption in food processing, the focus on additive manufacturing or 3D printing technologies has dramatically increased due to its accuracy, precision and reproducibility in the processing of complex structures. The most common 3D food applications adopted by the scientific and research communities are the application of novel food formulations, customized textures, texture variation and modulation as well as the full sensory design. As an emerging and integral application of additive manufacturing, 4D printing presents a new approach of processing, for the first time, dynamic food structures with time- and stimuli-dependent behavior. Such behaviors include the pH-driven spontaneous color change, shape morphing and cell culturing. In particular, the structuring of food structures which exhibits thermal-driven evolving deformations presents an immense potential for integration in the textural design of foods.

Currently, for structuring of shape morphing foods using 4D printing, polysaccharide-based material systems are mainly used in the form starch-based and hydrocolloid-based foods. For achieving the shape morphing effect, two stimulation methods are used which are hydration and dehydration methods. Considering shape morphing of starch-based materials through dehydration stimulation, the behavior is elucidated in-relation to energy/mass transfer, applied design and contraction mismatch between (bi-layer) active-passive or active-active layers while the mechanistic effect of thermal transitions is under-studied. In the presented research, characterization of the effect of protein-starch thermal transitions on shape morphing kinetics was performed on a hydrated wheat starch-soy protein material system. The influence of the geometric design was eliminated by printing uniform planar active starch-based layers on a single passive layer where the simple uniform 2-dimensional bending behavior was characterized using a computer vision method. As for the thermal stimulation methods, microwave and oven drying were used. For characterization of the effect of starch gelatinization on the shape deformation, the gelatinization kinetics were manipulated thorough variation of hydration and protein concentration inducing inhibition in water-mobility and varying starch-protein interactions.

Finally, by elucidating the effect of thermal transitions on the shape morphing kinetics of 4D printed structures, the control over textural effects through shape morphing can be achievable in the assembly of complex 3D structures.

Emerging processes & hurdles technologies

Oral

Improving the quality 3D printed food products by the full control of the printing movements and material deposition

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3D Food Printing is a promising technology that converts a digital model into edible food structures. Its nature, with extraordinary degrees of freedom, makes creating food structures impossible to realize with traditional manufacturing technologies. The interest of researchers and food industries in 3DFP is exponentially increasing due to the great opportunities for market innovation, on-demand productions, personalized food manufacturing, novel sensory perceptions, etc. However, to build 3D printed food products, there is the need to use CAD software to design the digital model and, second, to use slicing software to define the printing conditions and to convert the digital model into G-codes consisting of the information for printing movements and materials deposition. Such software contains limitations that hinder the creation of precise 3D food structures and the obtaining desired functionalities (i.e. texture, structural stability, etc.); such limitations also generate several difficulties in understanding the underlying causes and effects. For instance, the slicing software allows only limited printing paths that often reduce the structural stability of 3D-printed food products. We used a novel approach based on the concept of Full Control G-codes that allows the user to define any print-path segment and control all printing parameters. After defining digital models with different levels of complexity in terms of shape, dimensions and internal structures, 3D printing experiments have been performed by using a printable cereal-based food formula. Both the traditional printing approach and the innovative G-code designers have been used. The obtained samples have been compared not only in terms of the printing fidelity of the digital model but also in terms of printing efficiency by analyzing the printing time, the ratio between printing and non-printing movements, the capability of slicing complex structures and the time for slicing such digital models. Results showed the superior quality of samples obtained by the novel approach and open for creating innovative food products with a high level of structural complexity with several benefits on sensory properties and consumer acceptance.

Oral

3D printing of hydrocolloid gels for food applications.

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Keywords: Processing, Product,

3D printing has been a growing field for about 15 years. It consists of manufacturing a structure by additive deposition of materials. The most are those developed for printing plastics but other systems are being finalized, such as home printing. In the world of the food industry, relatively few studies have been conducted and target markets remain still to be expanded. Currently, potential clients are of two types: the hospital environment and ultra-advanced technical areas (aerospatial/army). The advantage of 3D printing in both cases, is the possibility of a personalized and concentrated nutritional source, while being able to structure the matrix. It is within this framework that our study, where we seek to develop high printability inks, presenting a high added nutritional value obtained through the inclusion of by-products. Thus, the development of advanced technology with a sustainable development objective reuse ‘waste’ from side streams.

Emerging processes & hurdles technologies

Oral

Die extrusion of highly concentrated systems; from theory to 3D food printing

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The processing of highly concentrated food systems via extrusion has always been a common processing operation. However, its importance is growing, with the increasing production of meat replacers, emergence of 3D-food printing and increasing importance of processing low moisture foods, to minimize energy intensive processes such as drying. During extrusion a material is forced to flow through a die by applying a certain pressure. The required extrusion pressure is typically estimated from the rheological properties of the material, the dimensions of the die and the required flow rate. The flow of highly concentrated systems is, however, inherently complex and care should be taken when translating apparent rheological properties obtained from rheological measurements to practical applications. Rheological properties are often directly inferred from torque-displacement data, while the actual flow of the material can show non-idealities that vary depending on the flow conditions. Examples include wall slip and shear-induced migration, which both lead to the underestimation of the determined viscosity. Given the large variety of materials being tested for extrusion applications, a deeper understanding of the flow behaviour would reduce trial-and-error approaches for optimization processes.
The aim of this contribution is to translate the knowledge obtained from fundamental research about suspension flow to practical solutions for extrusion challenges, focusing on 3D-printing of food materials. It centers around several studies performed in our research groups. To identify wall slip and shear-induced migration, work is presented that involved a high-pressure capillary rheometer, equipped with a set of smooth and custom-made rough dies. Results show the risk of relying on apparent rheological properties and help improve the mechanistic understanding of observed non-idealities. A translation is then made to 3D-printing applications. A landscape of printable recipes and processing conditions was created by using a custom-made ram extruder. Different ways to manipulate this determined landscape are then discussed based on the fundamental understanding of suspension flow. This contribution will further improve the adaptability of both researchers and industry with respect to changes in composition and/or processing conditions of highly concentrated food systems during extrusion.

Emerging processes & hurdles technologies

Oral

A step towards personalized food – Rheological requirements of cereal-based bio-inks for food 3D printing

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Using the 3D printing technology for food, it is possible to extent the limits of conventional manufacturing processes. By depositing the printing material layer by layer, it is possible to create define and customized structures with new texture profiles. This simple process offers the opportunity to improve food sustainability as it can, for example, by enabling on demand manufacturing. To create new cereal-based bio-inks, it is necessary to choose appropriate raw materials with suitable properties. Therefore, it is important to investigate the printing behavior of food materials during the 3D printing process. The rheological profile of the printing material needs specific properties, like extrudability through the tip of the nozzle and stability of the object after depositing. Due to the requirements of the printing process shear thinning and thixotropic behaviour are assumed to provide good printing quality. However, it is still unclear which material properties are dominating printing behaviour and thus mainly influence printing material properties.
To evaluate this behaviour, the three interval thixotropies test (3ITT) was adapted to the conditions of the printing process. The cereal-based food ink (starch, soy protein isolate) was altered with different hydrocolloids (MC, HPMC, xanthan, alginate, starch) to simulate the influence of network strength on the printing accuracy. In addition to that, starch from different sources were used to investigate the influence of particle size and surface properties on printing behavior. The deformation of the inner structure of the food ink during the imitated 3D printing process ranged from 48% (HPMC) to 78% (pre gelatinized starch). This led to a significant difference in printing performance. Correlation of rheological behaviour with printing performance, detected by image processing, suggested a linear relationship between network strength and printing accuracy ($R^2>0.89$). Additionally, the printing performance of starches from different sources (wheat, rice, potato) was shown to be mainly influenced by starch particle size rather than by the interaction of starch particles and soy protein isolate. These findings can help to find appropriate raw materials for the 3D printing process and thus by creating foods with new texture on demand, contributing to counteract food waste.

Emerging processes & hurdles technologies

Oral

Extrusion and rheological behavior of zein plasticized by glycerol and an active pharmaceutical ingredient to obtain 3D printed tablets

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Zein is the major storage protein extracted from corn kernels (3-5%db). It is a natural thermoplastic biopolymer that can be extruded once properly plasticized by glycerol as standard plasticizer. Among various Active Pharmaceutical Ingredients-Ionic Liquids (API-IL), which are considered as promising compounds for future drugs because of better stability and bioavailability, [Lidocainium][Ibuprofenate] has a triple interest: (i) a plasticizing effect on biopolymers and two therapeutic roles as (ii) local anesthetic and (iii) anti-inflammatory. This opens prospects to obtain customized edible delivery systems based on zein by additive manufacturing in the molten state. To do this, the rheological properties are a key parameter of the material.
Previous work showed that the glass transition temperature (Tg) of zein can be lowered from 80 to 42°C by adding 20w% ??glycerol as plasticizer. The composition (Z20GLY) can be extruded at 130°C using a co-rotative twin-screws microcompounder. Its apparent viscosity determined in steady-state flow increases with residence time due to protein aggregation, from 1kPa.s to 5kPa.s after 10min. Then, for short residence time (≈3min), it can be 3D printed by hot melt extrusion at 130°C. The substitution of glycerol by [Lidocainium][Ibuprofenate] leads to a Tg at 60°C and to a faster increase of viscosity. Unexpectedly, in the case of a partial substitution of glycerol, the apparent viscosity increases less rapidly, especially for material Z10GLY10LI containing 10w% of each plasticizer. The evolution of its flow curve was monitored as a function of the residence time by varying the rotation rate of the screws of the microcompounder. After applying the Rabinowitsch corrections, in order to consider the shear-thinning behavior of the material according to a power law, a progressive shift was observed towards high viscosities.
Several hypotheses can explain the limitation of the thermal aggregation of the protein matrix induced by the partial substitution of glycerol by API-IL. They will be mentioned during the presentation. From a practical point of view, this work highlights the possibility of optimizing the processability of the plasticized zein by the formulation, in particular for additive manufacturing, in which the residence time during processing can vary a lot.

Emerging processes & hurdles technologies

Oral

Development of edible filament for 3D printing of fully biodegradable robotic components

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Development of edible filament for 3D printing of fully biodegradable robotic components

Edible, soft robots are biodegradable when discarded in the environment and digestible upon consumption by humans and animals. Robotic components such as soft actuators or flexible sensors with complex geometric designs have been fabricated using Fused Deposition Modelling. Fused deposition modelling (FDM) is an additive manufacturing technique developed for 3D of printing plastics. It is a robust technology which enables manufacturing of complex structures with embedded functionality. Certain proteins have thermoplastic behaviour and via plasticization can be processed into edible filament that is suitable for 3D printing. Therefore, the aim of this study was to develop and characterize protein-based edible filaments, and investigate their 3D-printing performance using FDM. Selected proteins i.e. zein (corn protein), gluten (wheat protein), and caseinate (milk protein) were plasticized with glycerol to create powdery mixtures. These mixtures were processed into edible filaments using a mini-extruder. The thermal and mechanical properties of the protein-glycerol mixtures were characterized by differential scanning calorimetry (DSC) and closed-cavity rheology (CCR). The obtained edible filaments were characterized in terms of mechanical properties using texture analysis (e.g. flexibility) and 3D-printing performance. Results show that it is feasible to produce edible filaments using plasticized protein materials, and the 3D-printing performance of the filament is influenced by its formulation. Finally, an edible exoskeleton for a pneumatic actuator was created using edible filaments as proof of principle. This work contributes to the development of 3D food printing and will open up new avenues for fully biodegradable and edible robots.

Oral

Synergistic antimicrobial action between food processing methods and food-grade compounds

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We hypothesized that it is possible to accelerate microbial inactivation rate in foods through accumulation of complementary stresses within bacteria by a rational combination of food processing methods and food-grade compounds. We explored synergistic antimicrobial effect between mild natural antimicrobial compounds such as gallic acid, curcumin, cinnamaldehyde and eugenol and three processing methods: ultraviolet (UV)-A light, low and high frequency ultrasound and mild thermal treatments. We also developed mechanistic understanding behind improved microbial inactivation rate. Model foods we tested are fresh produce, liquid beverages and low moisture foods such as powdered infant formula. The bacteria we tested include *Escherichia coli* O157:H7, *Listeria innocua*, *Salmonella* Typhimurium and *Cronobacter sakazakii*. A combination of ultraviolet-A light with natural compounds significantly accelerates microbial inactivation rate in liquid medium as well as fresh produce surface with as much as 3-5 log reductions within 20 minutes. The antimicrobial treatment is also effective against biofilm. The synergistic antimicrobial action depends on membrane pemeablization by UV-A light that increases the update of antimicrobial compounds, which in-turn produces cascade of antimicrobial effects due to accumulation of oxidative stress. Similar acceleration in microbial inactivation was also observed by combining low (20 kHz) or high (1 MHz) frequency ultrasound with natural compounds on biofilms, liquid foods and fresh produce. We found that the antimicrobial mechanism differed significantly between two ultrasound wavelengths, with low frequency primarily causing membrane damage and high frequency primarily producing oxidative stress within cells. Interestingly, synergistic effect of thermal treatment with antimicrobial compounds in low moisture foods was highly dependent on the water activity and the macronutrient composition of foods. Subsequent analysis with qRT-PCR and biophysical methods demonstrated that bacteria responds to stresses from low water activity and antimicrobial treatment by changing its membrane fatty acid composition that lowers its fluidity, reducing its metabolic activity that lowers uptake of antimicrobial compounds and altering the expression of several stress-response genes such as those responsible for producing osmoprotectants. Thus, our presentation will describe the opportunities and limitations of our approach and advance the understanding of how bacterial survival strategies affect efficacy of synergistic antimicrobial treatments.

Emerging processes & hurdles technologies

Oral

Ultrasound-assisted hot air drying for improving drying kinetics and preserving amylolytic activity in malted cereals

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Although conventional hot air drying is a consolidated technology worldwide, it is still considered an energy-consuming process in food applications. These characteristics play an important role in processes that are already time-consuming, such as malting. In this sense, the present study aimed at applying ultrasound (US) in assistance to hot air drying to accelerate drying kinetics of post-sprouted wheat and barley grains and to preserve their resulting amylolytic properties. For this, post-sprouted wheat and barley were subjected to conventional hot air drying and to US-assisted hot air drying, both at 50 ºC. Drying kinetics were evaluated and the alpha- and beta-amylase activity of the produced radicleless malts was determined. Both cereals took ~55% less time to reach a moisture content of 10% (d.b.). The Page model was able to accurately described the drying curves with a $R^2_{adj}>0.98$ and a RMSE<0.3. Drying rates were improved by 129% and 98% in the case of wheat and barley, respectively. Alpha-amylase activity showed higher values for US-assisted dried malts (88% and 39% for wheat and barley, respectively) compared to conventionally dried ones. In regards to the beta-amylase activity, wheat dried by the US-assisted process showed 10% higher values when compared to conventionally dried ones. Beta-amylase activity of barley remained constant unchanged. Besides an improvement in the process kinetics, such results indicate the potential application of to improve the starch saccharification capacity of the resulting wheat malt, by means of both dextrin formation as well as maltose units' release. On the other, barley dried with the assistance of US had higher capacity to promote dextrin release compared to conventionally dried malts. The different characteristics of the resulted products can be used and combined to improve a given food application, such as brewery or baking, for example.

Oral

Storage stability of ultrasonic compression nutrition bars: Predicting temperature effect

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Nutrition bar texture change during storage is widely observed. It is essential to determine the change in mechanical properties of bars for shelf stable products within the expected shelf-life of one year. The stability of long shelf-life products typically are studied under accelerated conditions of higher temperature. Nutrition bars have glass transition temperature close to storage temperature. Therefore, the accelerated studies at higher temperatures may not provide an accurate shelf life prediction.
The objective of the study is to evaluate the effect of storage temperature for prediction of shelf-life of nutrition bars produced by ultrasonic compression.
Wheat flour was used for ultrasonic compression (UC). Bars were fabricated with an ultrasonic welding equipment. Flour with 22 % moisture was placed in a mold and horn was lowered until a force of 222N was reached which triggers welding. Weld time and percent amplitude were selected as processing parameters. Bars were sealed in pouches and stored at temperatures of 23, 40 and 50 C for 9 months. Periodically, samples were pulled out and mechanical properties were determined using a texture analyzer. Fracture stress change was calculated as a function of time at each temperature. Kinetic models were developed to determine the shelf life of products. Thermal analysis were conducted to determine the effect of storage on glass transition temperature of products.
UC nutrition bars have 16-17 percent moisture. The glass transition of bars occurs over a temperature range of 40 and 70 C with a mid-temperature of 60 C. After 8month of storage, glass transition appears to expand over a larger temperature range of 40 to 110 C with a mid-temperature of 75 C. While the storage temperature of 23 C assures the bar to stay in the glassy state where the molecular level movements and moisture diffusion is restricted, accelerated storage temperatures causes the bar to be transitioning from glassy to rubbery state allowing the moisture redistribution which lead to firming of product.
Development of predictive capability of the shelf-life for bars accurately will lead to optimization of storage conditions for food processors and to serve the consumer needs.

Oral

Production of nutrient bars by ultrasonic compression: Optimal processing window predictability

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Conventional nutrition bars are made by mechanical compression of cereal flours. Typically, a force of 9,000 N is applied. Agglomeration of particles under mechanical compression requires the use of binders like sugar syrup. Bar texture is negatively impacted by moisture during storage. Ultrasonic compression (UC) is a novel approach to produce nutrient-dense bars with reduced moisture thereby increasing the shelf life. Temperature increase during ultrasonic welding process due to conversion of mechanical energy to heat aids agglomeration of particles.

The objective of the study is to evaluate the effect of various cereal flours on ultrasonic compression parameters to produce nutrition bars with structural integrity and desired mechanical properties.

Wheat, corn, oat, and buckwheat flours were used. UC bars were fabricated using ultrasonic welding equipment working at 20 kHz. Flour with 22 % moisture was placed in a mold and the horn was lowered with a 0.015 m/sec velocity until a trigger force of 222N was reached after contact with flour. Weld energy and percent amplitude were selected as processing parameters and welding time was recorded to establish a process window for production of bars with structural integrity. Mechanical properties tests were carried out using a texture analyzer and fracture stress was calculated. Temperature increases for the process were determined with an infrared camera. The relationships among fracture stress and UC processing parameters and flour properties were developed.

A “successful” bar production parameters region was established within the envelope of weld, energy, percent amplitude, and weld time. The region remained within 2200-3750 J, 60-100% amplitude, and 2-3 seconds of weld time. Processing window showed differences among flours due to differences in their composition and particle sizes. A temperature contour plot indicated a temperature range of 50-65 C for bar production. Fracture stress of the bars varied among flours, with the highest, 3341 kPa, for whole wheat flour and the lowest, 242kPa, for oat flour.Development of a predictive capability for fracture stress of bars will lead to optimization of UC parameters for various flour systems to better serve both processor and consumer needs.

Emerging processes & hurdles technologies

Oral

Exploration of ohmic-sonication technique for the shelf life extension of apple juice

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Objective: Apple juice is pivotal food commodity naturally consumed for its nutrition rich and health promoting attributes for normal and diseased persons. Methods: Current research was performed to evaluate the nutritional composition, physico-chemical composition, microbiological and sensorial stability of apple juice subjected to different treatments of ohmic heating – sonication techniques as T1 (ohmic heated at 75oC for 60 sec at 220V), T2 (sonicated at 8 min at 20 kHz), T3 (ohmic-sonication at 75 0C for 60 sec at 220 V), and T4 (ohmic-sonication 8 mint at 20 kHz). Results: The results elucidated significant ($p<0.05$) reduction in pH values of apple juice from T0 – T4 from 3.78 – 3.5, respectively. Among the total carotenoids T3 (sonication-ohmic) showed the highest contents i.e., 108 µg mL-1. The storage resulted in significant ($p<0.05$) in antioxidant activities (i.e., DPPH activities) of apple juice from T0 – T4 from 289 – 317 ug/g, while among the treatments the highest DPPH activities were noticed in T3. The maximum vitamin C was found in T3 i.e., 5.92% on 14th day of storage. Titratable acidity increased from 0.31 to 0.45 on storage apple juice from 0 – 14th day of storage. The total soluble solids significantly ($p<0.05$) increased from 9.9 – 13.4% from T0 – T4 on storage of 0 – 14th day. While, the microbial numbers revealed the increase in log CFU/mL from 0.91 – 2.31 on storage of 0 – 14th day. Overall sensory acceptability showed the highest acceptability of the apple juice was T3 which showed the highest color, flavor and overall acceptability of apple juice. Conclusion: Conclusively, the research shows potential use of ohmic heating–sonication at 75 0C for 60 seconds at 220 V as a viable strategy of choice for shelf life extension of value added foods products to extend the shelf stability and to the improve the microbiological safety of apple juice.

Oral

Ultrasound-assisted extraction of oilseeds: study on hempseeds (Cannabis sativa L.)

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There is a growing interest for ultrasound inclusion in extraction of oil (soybean, almond, sunflower), proteins and bioactive compounds (polyphenols, polysaccharides, anthocyanins) from different sources. It is commonly agreed that ultrasonic assisted extraction (UAE) advantageously improves conventional oil extraction technology because of high extraction yield, shorter extraction time and low energy demand. During the UAE of vegetable materials, the result of the cavitation phenomena is an enhanced material transfer from inside the cells to the external environmental.

Oilseed-matrix consolidation is a crucial factor when talking about oil expression because, as the cake consolidates, the coefficient of permeability inevitably decreases. Thus, any treatment that extensively ruptures cell walls reduces rigidity and hardness of the oilseed press-cake, while improving the oil expression. Such process intensification was investigated in the present study through the introduction of the ultrasound (US) technology. Screw pressing of Cannabis sativa L. seeds was operated using a pilot scale equipment set at three different pressures to understand the correlation with the ultrasound effectiveness. Samples of non-exhausted press-cakes were tested for objective instrumental indices of compressibility and oil expression yields prior and after the US treatment.

Main results are as follow. US led to a drag resistance reduction within press-cakes, improving oil flowability through a decrease in the material cohesiveness and adhesiveness. Consistently, sonication favoured oil extraction yields and oil antioxidant capacities, which increased with respect to the untreated samples, respectively equal to +19.2% and + 29.4% for the press-cake screwed at low pressure, to +21.8% and + 49.3% at medium pressure, and to +15.4% and + 0.5% at high pressure. Overall, US highest effectiveness was accounted for samples screwed at medium pressure.

In conclusion, press-cake compressibility can be sucessfully described by macroscopic texture parameters; indeed, their decrease is linked to higher oil expression efficiencies. Sonication can help boosting oil extraction yields reducing drag resistance within the mechanical screwing equipment. These outcomes offer good potentials for US application in the hempseed technology and, more extensively, in the oil seed industry.

Emerging processes & hurdles technologies

Poster

Influence of different lactic acid bacteria strains and milling process on the solid-state fermented green and red lentils (Lens culinaris L.) properties including gamma-aminobutyric acid formation

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Keywords: Lentils, Solid-state fermentation, Lactic acid bacteria, Gamma-aminobutyric acid, Biogenic amines,

The aim of this study was to evaluate the influence of lactic acid bacteria (LAB) strains (Lactiplantibacillus plantarum No.122 and Lacticaseibacillus casei No.210) and milling process on the solid-state fermented (for 24 h, at 30 °C) green and red lentils (Lens culinaris L.) properties, chiefly pH, LAB viable counts, colour coordinates, free amino acid (FAA) profile, γ-aminobutyric acid (GABA) and biogenic amine (BA) concentrations, fatty acid (FA) and volatile compound (VC) profiles. Results showed that both of the tested LAB strains are suitable for the fermentation of lentils: pH of fermented lentils was <4.5 and LAB viable counts >8.0 log10 colony-forming units (CFU)/g. A very strong negative correlation was found ($r=-0.973$, $p \leq 0.0001$) between LAB counts and pH of the samples. Also, fermentation and milling process were significant factors towards colour coordinates of the lentils. In most of the cases, solid-state fermentation (SSF) increased essential FAA content in lentils; however, some of the non-essential FAA content was reduced. SSF significantly increased GABA concentration in lentils and milling process was a significant factor on GABA content of the samples ($p \leq 0.05$). The main BA in lentils was spermidine, and SSF decreased their total BA content (34.8% on average in red lentils and 39.9% on average in green lentils). The main FA in lentils were linoleic and oleic. The main VC in lentils were hexanal, 1-hexanol, hexanoic acid, D-limonene, and (E)-2-nonen-1-ol. Furthermore, most of the VC showed significant correlations with pH of lentil samples, LAB counts and FA content. Finally, the LAB strain used for fermentation and the milling process of lentils are significant factors for most of the analysed parameters in lentil. Moreover, despite the higher GABA concentration found in green non-milled SSF lentils, application of combined milling and SSF is recommended because they showed the lowest BA content in addition to higher essential FAA and GABA concentrations.

Emerging processes & hurdles technologies

Poster

Bio-Converted Spirulina for Nutraceutical Chewing Candy Formulations Rich in L-Glutamic and Gamma-Aminobutyric Acids

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Keywords: nutraceuticals, fermentation, gamma-aminobutyric acid, L-glutamic acid, fatty acids, emotions,

This study aimed at evaluating changes of microalgae Spirulina during its fermentation with Lactiplantibacillus plantarum No. 122 strain, and further at incorporating Spirulina bio-converted for nutraceuticals rich in L-glutamic (L-Glu) and gamma-aminobutyric acids (GABA) into sucrose-free chewing candy (gummy) preparations. Fermented spirulina had higher b* (yellowness) coordinates than untreated (non-fermented), and fermentation duration (24 and 48 h) had a statistically significant effect on colour coordinates. The highest contents of L-glutamic and gamma-aminobutyric acids (4062 and 228.6 mg/kg, respectively) were found in 24 and 48 h-fermented Spirulina, respectively. Fermentation increased the content of saturated fatty acids and omega-3 in Spirulina, while monounsaturated fatty acids and omega-6 were reduced. The addition of fermented Spirulina (FSp) significantly affected hardness, decreased lightness and yellowness, and increased the greenness of chewing candies. All chewing candy samples (with xylitol) prepared with 3 and 5 g of FSp and 0.2 µL of Citrus paradise essential oil received the highest scores for overall acceptability, and the highest intensity (0.052) of emotion "happy" was elicited by the sample group containing xylitol, agar, ascorbic acid, 3 g of FSp, and 0.1 µL of Mentha spicata essential oil. As an outcome of this research, one may conclude that fermented Spirulina has significant potential as an innovative ingredient in the production of healthier sucrose-free nutraceutical chewing candies.

Emerging processes & hurdles technologies

Poster

Characterisation of Lacto-Fermented Cricket (Acheta domesticus) Flour and Its Influence on the Quality Parameters and Acrylamide Formation in Wheat Biscuits

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Keywords: cricket flour, fermentation, biscuits, acrylamide, emotions, biogenic amines,

The aim of this study was to evaluate the influence of different amounts (40, 80 and 100g) of non-fermented and fermented (with Lactiplantibacillus plantarum No. 122 and Lacticaseibacillus casei No. 210) cricket flour (Cr) on the quality characteristics and acrylamide formation in wheat biscuits (WB). The main formula for WB preparation consisted in 280g of wheat flour, 100g of margarine, 50g of saccharose, 3g of vanilla sugar, 50g of eggs, 1.5g of salt and 2.0g of baking powder. It was established that the highest lactic acid bacteria (LAB) number was in 48h with No. 122 fermented Cr (11.8 log10 CFU/g) and the lowest pH (4.34) was obtained after 48h of Cr fermentation with both the tested LAB strains. The total colour difference were in the range of 17.54 to 22.08 and, in every case, fermented samples were clearly distinguished from untreated ones. Fermentation increased tyramine content in Cr (from 13.0 to 29.2 times). The main FA in Cr were palmitic acid, stearic acid, octadec-9-enoic acid and linoleic acid. The lowest acrylamide content (84.1µg/kg) was found in WB with 40g of Cr fermented with No. 210. Significant differences in WB overall acceptability were not found. However, the highest intensity of emotion "happy" was elicited by WB with 80g of Cr fermented with No. 122. Due to the demonstrated decrease of acrylamide content, fermented Cr can be considered a beneficial ingredient for the manufacture of WB.

Poster

Effect of ultrasound on the physical and chemical properties of alginate-based marjoram essential oil nano-emulsions.

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Marjoram essential oil (MEO) is a natural preservative rich in compounds with antimicrobial properties, which can be applied in the form of emulsions in active coatings in order to improve foods' shelf life. Emulsion droplet size reduction to the nanoscale (< 200 nm) may improve coating stability, transparency, and antimicrobial activity. This work aimed to evaluate the effect of ultrasound treatment on the physical and chemical properties of alginate-based marjoram essential oil nano-emulsions. A coarse emulsion containing water, sodium alginate (1%), MEO (1%), and Tween 80 (1%) was prepared using an Ultra-Turrax at 10,000 rpm for 3 min; this emulsion was then homogenized with an ultrasonic probe in order to produce the nanoemulsions. Six ultrasound treatments were tested, varying process time (1 to 5 min) and power (150 to 250 W), resulting in six coating forming nanoemulsions (CFN) (1min/150W; 1min/25 W; 3min/150W; 3min/250W; 5min/150W; and 5min/250W). The effect of ultrasound treatment on the oil droplet size, polydispersity index, zeta potential, oil retention, turbidity, viscosity, and visual stability were investigated. CFNs were within nanoscale, except that produced at 5min/250W. Long-term high-energy treatments (5 min/250W) increased oil droplet size and polydispersity index, and reduced zeta potential to critical values (33 mV) to prevent oil droplet agglomeration. Ultrasound treatment did not affect oil retention (CFNs mean oil retention was 72%). Turbidity was associated with oil droplet size, as reduced oil droplet size CFNs showed high optical transparency. In general, CFNs behaved as Newtonian fluid, and long-term high-energy treatments promoted viscosity reduction. Visual stability against phase separation was affected by ultrasound treatment. Long-term high-energy treatments showed visual phase separation, confirming coalescence problems previously described in the droplet size and polydispersity index analysis, due to a possible overprocessing. Processes performed at milder conditions (150 W: 3 and 5 min; 250 W: 1 and 3 min) allowed to produce CFNs within the nanoscale, with high essential oil retention, good optical transparency, and stable against coalescence and gravitational phase separation, being promising for the application as active coating in plant or animal food products.

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Emerging processes & hurdles technologies

Poster

Search for a harmonized preparation protocol for stabilizing and maintaining the physical properties of cinnamom essential oil nanoemulsions when incorporated into active coatings.

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Size and uniformity of oil droplets in emulsions are directly related to emulsion stability.Nanoemulsions with droplets smaller than 200 nm have high kinetic stability.This study aims to analyze the effect of homogenization method and sequence of preparation steps on the physical properties of coating forming emulsions/nanoemulsions.Four preparation treatments were tested to produce alginate-based coatings incorporated with cinnamon essential oil (CEO) emulsion/nanoemulsion. Primary emulsions containing water, CEO and Tween 80 (PE), or sodium alginate, Tween 80 and CEO (PEA) were prepared using an Ultra-Turrax IKAT25 at 10.000 rpm for 5 minutes. PE and PEA were then homogenized in ultrasound, generating the nanoemulsions NE and NEA, respectively. Finally, a fifth nanoemulsion (NEAT) was prepared by homogenizing NE with a solution of sodium alginate in the Ultra-Turrax at 10.000 rpm for 5 minutes. The components of all emulsions (alginate, CEO and Tween 80) had a final concentration of 1% (w/w). Mean particle size (Z-Average), polidispersity index (PDI) and Zeta potential values measured for each treatment were: PE: 91.32 ± 1.2 nm, 0.59 ± 0.01, and -11.8 mV ± 0.8; PEA: 214 ± 1.8 nm, 0.67 ± 0.02, and -31 mV ± 1.2;NE: 49.21 ± 0.2 nm 0.252 ± 0.00 ,and -10.7 ± 0.0 mV ;NEA: 205.2 ± 4.6 nm, 0.503 ± 0.11, and -48.7 ± 3.2 mV; NEAT: 107.81 ± 0.6 nm, 0.81 ± 0.01, and -37.2 ± 3.0mV. Primary emulsions (PE and PEA) showed Z-Average and PDI values superior to those obtained by the emulsions produced in ultrasound (NE, NEA and NEAT), proving the superiority of ultrasound in producing smaller droplets with greater uniformity. NE showed the lowest PDI and Z-Average results.Emulsions containing sodium alginate (NEA and NEAT) showed different values ??of PDI and Z-Average, indicating that the preparation method affected the physical characteristics of the oil droplets.These emulsions were more negatively charged, probably due to the presence of sodium alginate.Based on these results, droplets size and distribution may be modulated according to preparation protocol. This is an important issue that should be further investigated to obtain a harmonized protocol and ensure the maximum efficiency of essential oils incorporated into active coatings.

Emerging processes & hurdles technologies

Poster

ASSESSING THE INFLUENCE OF BEHENIC ACID CONCENTRATION ON THE PHYSICOCHEMICAL PROPERTIES OF STRUCTURED LIPIDS PRODUCED BY ENZYMATIC INTERESTERIFICATION

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Keywords: Behenic acid, Structured lipids, Interesterification,

The need for effective dietary approaches that act in a non-aggressive way to control obesity has encouraged the production of structured lipids (SLs) that are restructured triacylglycerols obtained by chemical and/or enzymatic interesterification or transesterification. Enzymatic interesterification reaction is advantageous since it allows a great control over the positional distribution of fatty acids in the glycerol backbone. Behenic acid, obtained by the hydrogenation of crambe oil, is a long chain saturated fatty acid widely used as a substrate in the production of these SLs, as it reduces lipid absorption. Peanut and soybean oil are composed of essential fatty acids and present more than 80% of mono- and polyunsaturated fatty acids. Thus, this work aimed at producing structured lipids from varying ratios of peanut oil (P), soybean oil (S), and fully hydrogenated crambe oil – FHCO (C) mixtures by enzymatic interesterification (Lipozyme TL IM) and to evaluate their physicochemical properties. The mixtures ratio varied in order to have samples with 6, 18 and 24 % (m/m) of behenic acid. Interesterification caused an increase in crystallization time and a decrease in the solid fat content for all mixtures. The redistribution of the fatty acids in the glycerol backbone changed the thermal behavior, leading to a decrease in the onset and end temperatures during crystallization, which indicates that new triacylglycerols were formed. As for the classes of acylglycerols, the amount of triacylglycerols was higher than the content of diacylglycerols and monoacylglycerols, inferring that the hydrolysis followed by esterification left a small amount of diacylglycerols and monoacylglycerols. Regarding samples consistency, the higher concentration of behenic acid favored to obtain samples with greater hardness. As conclusion, structured lipids containing different behenic acid concentrations were produced by enzymatic interesterification in order to obtain lipids with antiobesity potential and varied functionalities of technological application.

Emerging processes & hurdles technologies

Poster

Extraction processes used for botanical ingredients: applications in ready-to-drink beverages

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Keywords: Processing, plant-based, beverages, extraction, botanicals,

Plant-based, botanical ingredients have been processed and extracted for use in food and dietary supplement applications to treat ailments and improve health for centuries. Although botanicals have a long history of use worldwide, they have experienced a recent rise in consumer demand and consumption due to their clean label, as well as their functional and nutritional benefits. In the United States, most botanicals are sold as dietary supplements, with over 1,600 plant materials and their derivatives being sold as dietary supplements, and over 250 botanical extracts being added to food. Botanicals in foods and beverages are frequently used in the form of concentrated extracts; their functionality is broad, ranging from color, fragrance, flavor, thickening, preservative activity, and functional benefits. Using a botanical extract in a beverage that was designed for use in a dietary supplement is not ideal and can result in product development challenges and process optimization opportunities. Extraction techniques and processing parameters, such as time, temperature, pressure, solvent, and plant matrix properties, are critical to the success of a botanical extract for use in a food or beverage. Botanical compounds can be extracted from plant materials using a variety of traditional and non-conventional processing methods. Many traditional extraction methods use the extraction ability of different solvents and the application of heat and/or mixing. Non-conventional methods are more newly developed processes that typically produce a higher quality of extract, have a reduced operational time, better yield, and are more environmentally friendly due to decreased use of synthetic and organic chemicals. Examples of traditional extraction methods are maceration and hydrodistillation, while non-conventional methods include supercritical fluid extraction, ultrasound assisted extraction, and pressurized liquid extraction. There are many factors that impact the quality and purity of a botanical extract; optimizing the extraction process for a botanical ingredient is critical to its successful application in a ready-to-drink beverage.

The views expressed are those of the author and do not necessarily reflect the position or policy of PepsiCo, Inc.

Emerging processes & hurdles technologies

Poster

Understanding the fibration in plant proteins during high moisture extrusion

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Plant based meat-analogues have become very popular in the last few years. Using high moisture extrusion-cooking (HMEC), globular plant proteins are transformed into a fibrous structure that intends to resemble the myofibrils of an
animal muscle. Understanding the mechanisms and conditions that allow the formation of the anisotropic structure could lead to an improvement in current products and innovation in the market.
The HMEC process can be decomposed into two main steps; an initial application of high shear at high temperature in a screw section of the water-rich protein mix is followed by a cooling through a long slit die. Current literature indicates that the apparition of the structure is caused by two mechanisms occurring in the cooling die. On the one hand, the deformation by elongation of the viscous mix orients the denatured proteins. On the other hand, a temperature gradient induced phase separation contributes to the oriented heterogeneous structure. A correlation between process conditions and rheological/structural properties is necessary to ascertain these mechanisms and build a predictive model. This presentation aims at reviewing the current understanding of formation of the fibrous structure in plant based meat analogs and underlining the technological and scientific gaps in this technology. Thermomechanical and structural properties of the products will be correlated to process conditions on the basis of experimental studies.

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Poster

Physical properties of gelatin active films incorporated with cellulose nanocrystals and "Pitanga" leaf extract encapsulated into double emulsion

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Edible films are thin and flexible materials produced from biopolymers. When carrying different components, such as active compounds (i.e., plant extracts with antioxidant and/or antimicrobial activities or encapsulated systems) and reinforcement nanoparticles, they are considered as active nanocomposites. The aims of this study were to produce active gelatin composite films by incorporation of "Pitanga" leaf extract (PLE) not encapsulated (NE) and encapsulated in W/O/W emulsion (DE) and of cellulose nanocrystals (NC) extracted from soy straw. The active nanocomposite films were produced by the casting method, using 4g gelatin/100g film-forming solution, 25g glycerol/100g gelatin, 0.25g NE or DE/100g gelatin and 4.5g NC/100g gelatin. Therefore, 6 treatments were produced: (i) Active films with NE without NC (F-NE) and with NC (F-NE/NC), and with DE without NC (F-DE) and with NC (F-DE/ NC), and (ii) control films without PLE and without NC (F-C) and with NC (F-NC). All treatments were then characterized in terms of microstructure, physicochemical, mechanical, and UV/Vis light barrier properties and antioxidant activity (AA). The results obtained were submitted to analysis of variance (one-way and two-way) and Tukey's test. The internal structure of the films (thickness ~80µm, $p>0.05$) was smooth and homogeneous in the films without DE and without NC, and less smooth and homogeneous in the DE and/or NC films. The presence of DE and NC decreased the water vapor permeability (WVP) of the films, especially in F-DE/NC, which showed lower WVP ($p<0.05$). The F-DE and F-DE/NC showed higher ($p>0.05$) tensile strength (80.5 and 150.0MPa, respectively) than the other treatments. The films showed good UV/Vis light barrier properties, being F-DE/NC>F-DE>F-NE/NC>F-NC>F-NE>F-C. The addition of NE and DE conferred AA to the films, and the F-DE kept the highest ($p<0.05$) AA. As conclusion, the addition of PLE activated gelatin films and mainly improved the mechanical and barrier properties to UV/Vis light, especially when PLE was encapsulated in W/O/W emulsion and combined with cellulose nanocrystals.

Emerging processes & hurdles technologies

Poster

Plasma activated water (PAW) for washing perishables to gently reduce the microbial load and the chemistry behind it.

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Minimally processed perishables have gained attention in recent years, due to the convenience and health aspects, which attract the attention of a growing public, who are looking for nutritional benefits in addition to practicality. Therefore, the aim of this research was to investigate the potential of plasma-activated water (PAW) at different temperatures to reduce the microbial load on perishables as well as the chemistry behind it (stability and duration of usability of the PAW.)
Cherry tomatoes, lettuce, apple and pears were treated with PAW at 20°C, 30°C and 40 °C for 1 to 5 minutes or tap water and stored for 2 weeks at 8°C. Directly after the treatment as well as for each storage point the microbiology was tested via platting dilutions on Endo agar (Enterobacteriaceae), Maltodextrose agar (Yeats and molds) and plate count agar (total aerobic mesophilic). The concentrations of H_2O_2, NO_2^- and produced in PAW were measured via The Amplex® Red Hydrogen Peroxide Assay Kit (H_2O_2) and the Nitrate/Nitrite colorimetric assay (NO_2^-). pH and the conductivity were also evaluated.
Based on preliminary results it was decided that a treatment of 3 min with PAW at 30°C as the optimal condition. The mentioned results are in comparison to the control and tap water sample. For the tomatoes a reduction of ~3 log10 (molds, Enterobacteriaceae, mesophilic bacteria) was achieved. A similar inactivation was noticeable for the lettuce 1.4 log10 for mesophilic bacteria, 2.1 log10 for Enterobacteriaceae and 2.9 log10 for molds. Also for the apples, a reduction of 1.5 log10 for mesophilic bacteria, 1.5 log10 for Enterobacteriaceae and 3.3 log10 for molds was achieved. For the pears, similar results as for apple were obtained. These reductions were stable over the storage period. Currently, the chemistry of the PAW is still under investigation.
PAW is a new and great addition for the sanitization of perishables, showing a good potential on the microbial inactivation. Its chemistry and usability need further investigation.

Poster

Quantitative assessments to characterise the antibiotic resistance of seafood microbial isolates

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Objective
The objective of this study was to evaluate the Minimum Inhibitory Concentrations (MIC) and the Non-Inhibitory Concentrations (NIC) of *Vibrio parahaemolyticus* isolates against aminoglycoside antibiotics.
Methods
Two *V. parahaemolyticus* strains (M5 and M15) isolated from Mediterranean mussels (*Mytilus galloprovincialis*) and identified by a PCR method with a target toxR gene were used in the study. A turbidimetric assay was implemented to investigate the antibacterial activity of gentamicin and tobramycin toward these isolates. The optical density was measured at frequent time intervals at 630 nm. The trapezoidal method was implemented for quantifying the area of the optical density versus time. Hereafter, the Lambert-Pearson model which is based on a Gompertz function was then applied to estimate the MIC and NIC.
Results
MIC and NIC of *V. parahaemolyticus* M5 for gentamicin were found to be 4.78 and 1.23 mg/ml, respectively. On another hand, *V. parahaemolyticus* M15 showed higher MIC (8.07 mg/ml) and NIC (1.36 mg/ml) values. The MIC and NIC of *V. parahaemolyticus* M5 for tobramycin were 2.05 mg/ml and 0.68 mg/ml, respectively.
Conclusions
This study demonstrated that turbidimetric assay was useful for the successful estimation of MIC and NIC against antibiotics. This method can be applied in order to obtain reliable results for MIC and NIC of *V. parahaemolyticus* and address current needs for identifying the antibiotic resistance of food-borne pathogens.

Emerging processes & hurdles technologies

Poster

Pulsed Electric Field pretreatment for cost and energy efficient processing of industrial peach cultivars

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In temperate climates, peach harvesting spans a short period, from mid-July to mid-September. In order for the fruit processing industry to prolong this period, certain cultivars are used which can be harvested up to late September. However, these cultivars exhibit increased firmness, requiring frequent cutting blade replacement, and resulting in low juicing yields. To avoid these issues, thermal pretreatment or prolonged ripening storage is required, causing significant handling and cost issues. Pulsed Electric Fields can soften plant tissues at a fraction of the energy required compared to thermal treatments. This work explores the applicability of PEF pretreatment on whole peaches, prior to juicing and cutting.
Mild PEF treatments (2.0 kV/cm,0-2.73 kJ/kg) were applied on whole peaches (Everts variety) subsequently assessed in terms of firmness, using a texture analyzer and puree yield using a benchtop screw juicer. Juicing efficiency was expressed as % of destoned fruit mass. Quality parameters such as total soluble solids, pH, color and Bostwick consistency were determined on the resulting purees. PEF treatments were compared to thermal blanching (90°C, 5 min) and freeze-thawing (-20°C, 25°C).
All PEF treatments led to a decrease in fruit firmness by 28% (10 kg/cm2) compared to untreated samples. This decrease was estimated to reduce the cutting blade replacement frequency from once every 8 h shift to once every 7 days. The decrease in firmness also led to a significant increase of juicing yield from 65% to 79%. A specific energy input equal to 0.2 kJ/kg was adequate to achieve this increase in juice yield, corresponding to energy savings of 170 kJ/kg, compared to thermal blanching. The quality parameters of the resulting puree were equivalent to those of untreated samples, except for lower but still within acceptable limits Bostwick consistency (8 cm/30 s). These results underline the applicability of PEF treatments in a real case industrial setting and highlight its suitability as an energy saving process.
Acknowledgment: This work was performed in the framework of the National Recovery and Resilience Plan "Greece 2.0" funded by the European Union-NextGenerationEU (Project No. FRUIVEF-TAEDK-06176).

Emerging processes & hurdles technologies

Poster

Optimized twin-screw enzymatic extrusion process to extract protein from micro and macroalgae

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Optimized twin-screw enzymatic extrusion process to extract protein from micro and macroalgae

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The objectives of this work are to highlight the potential of extrusion, coupled or not with enzymatic hydrolysis, applied to the valorization of macroalgae and microalgae. Twin-screw extrusion is a thermomechanical process consisting of two inter-meshing and co-rotating screws. One aspect of this work is to understand the mechanisms that lead to the physico-chemical changes of the bio-resources, in relation to the kinetic characteristics. This study will take into account the product-process coupling, in particular the relationship between the nature and composition of the substrats, the processing conditions and the final quality of the product, by integrating the rheological properties and the physicochemical factors involved in the processing.
The optimization of the process was done by means of a design of experiments (DoE). In this study, three variables were investigated including biomass flow rate, enzyme concentration, and screw speed. Results revealed that biomass flow rate and enzyme concentration presented significant effect on the release of protein and sugar respectively. Meanwhile, both biomass flow rate and enzyme concentration were shown to have the significant effect on the release of pigments. The results showed that the extraction rates of extrusion in the presence of enzyme are increased compared to extrusion without enzyme and enzymatic hydrolysis in biomass batch reactor.

Emerging processes & hurdles technologies

Poster

Cold plasma bubbles for apple juice preservation

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This study aimed to develop a cold plasma bubbling system to ensure the microbial safety and retention of quality attributes of apple juice by using a gas-liquid phase reactor. A Cold Plasma Bubble (CPB) reactor was developed to assess the antimicrobial efficacy against pathogens (*E. coli & Listeria monocytogenis*) in fresh apple juice using air as the inducer gas at various frequency discharges (500, 1000 and 2000 Hz), flow rates, and applied voltages. Further, optimal processing conditions were used to investigate the effect on the inactivation of undesirable endogenous enzymes such as polyphenol oxidase (PPO) and peroxidase (POD).

The CPB reactor was found to achieve the target minimum 5 log reduction in the population of pathogens in apple juice. Scavenging assays indicated the importance of reactive oxygen species (ROS), especially superoxide, to play a key role in the observed antimicrobial effects. Further, the optimal cold plasma processing conditions yielded up to 50% reductions in endogenous enzyme activities. The mechanisms of actions were eluded from in-situ diagnostics of the plasma discharge and the induced recreative metastable species. The energy efficiency of the reactor is quantified for the targeted antimicrobial effects.

In conclusion, the CPB reactor developed for this study demonstrated high efficacy in ensuring the microbial safety and retention of the quality attributes in apple juice while using air as the processing gas, which is free and abundant. This highlights the potential of this green processing approach as a cost-effective alternative to current conventional approaches.

Emerging processes & hurdles technologies

Poster

Selective extraction of monogalactosyldiacylglycerol from spinach by CO2 supercritical fluid

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Glycolipids are ubiquitous lipids in the membranes of plants, algae, bacteria and animals (1). In plants, galactolipids represent about 77% of fatty acid stocks (2). Upon stress or storage conditions, the glycolipid composition (content, structure) of plants, algae and bacteria can be modified (2–4). The glycolipids of plants and algae, being rich in polyunsaturated fatty acids (1), could be new sources of beneficial omega 3 for the human diet. However, the digestion and the digestive fate of glycolipids are still not well-understood. In addition, glycolipids are amphiphilic molecules with interfacial and biological activities (anticancer, antiviral) (5). To be able to study the properties of these molecules, it is essential to extract and purify fairly substantial quantities. Supercritical fluid extraction using carbon dioxide (SCF CO2) is an environmentally friendly method, low toxicity and compatible with food processes (6). This method has already been used to extract lipids (neutral and polar) from algae.

We developed an extraction process using SCF CO2 allowing the extraction of high quantity of plant glycolipids and compared it with a conventional extraction process.

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Emerging processes & hurdles technologies

Poster

The Joint Technological Unit Qualiveg3 “Integrated design of F&V processing routes”: objectives, research projects and expected results

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The *Unité mixte technologique* (UMT - Joint Technological Unit) is a partnership tool shared by a Technical Institute and an academic lab, supported by the French Ministry for Food to promote collaboration and projects. UMT Qualiveg3 “Integrated design of F&V processing routes” is carried by the CTCPA and INRAE.
There is a lot of pressure on the actors in the food chain. Indeed, many constraints exist at the production level, such as global warming and the reduction of inputs, to which must be added the obligations of processing, such as the reduction of losses and waste, the limitation of ultra-processed products, the reinforcement of quality and finally the evolution of distribution methods. How do we do this when we want to improve the system in a holistic way?
In this context, the objective of Qualiveg3 is to *develop a coherent and complementary set of tools and skills for all production, processing and distribution/consumption routes and a multi-criteria evaluation strategy for the design of healthier and more sustainable processed F&V products.*
The specific challenges of Qualiveg3 are (i) *process innovation* by studying the processes or process combinations that will enable us to revisit the conservation and valorisation of co-products, (ii) *innovation in the evaluation of qualities* and their consideration in the life cycle of the product by characterise different dimensions of quality using innovative tools at different stages of the technological itinerary, (iii) *develop basic and global tools for performance comparison allowing to integrate the different dimensions of quality (such as nutritional, microbiological, environmental, …)*
Three collaborative projects are already in progress (Tom’Health - Relationship between tomato growing conditions, processing and health effects / HiStabJuice – Establishing a strong and lasting international training network for innovation in food and juice industries: a 4D-research approach for fruit juice processing / DEMETER - Resource efficiency optimisation of 2nd class vegetables via biorefinery solutions to improve sustainability in the agrifood chain and climate change resilience).

Poster

Effect of Pulsed Electric Fields and Osmotic Dehydration on the shelf life of fresh-cut spinach leaves

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Fresh-cut spinach is commonly distributed in chilled storage, but due to its extremely rapid microbial spoilage it cannot be readily incorporated into ready-to-eat products (RTE). Conventional dehydration techniques are effective in tissue preservation, but the final product quality is far inferior from that of the initial fresh vegetable. Osmotic Dehydration (OD) provides a gentle dehydration to delicate plant tissues by immersion in a hypertonic solution. Pulsed Electric Fields (PEF) increase cell's permeabilization by exposing them to a high strength electric field and are suitable for enhancing mass transfer during OD. The aim of this work was to study the effect of PEF prior to OD on cut spinach shelf-life extension.

Fresh-cut spinach leaves were PEF treated (0.6 kV/cm, 20 pulses, 15 μs width). Samples were osmotically dehydrated (25°C, 60 min, 1:20 solid to liquid ratio) in solutions with 60% glycerol. Samples were stored at different storage temperatures from 4°C to 20°C and microbial and sensorial analyses were caried out. The kinetics of microbial growth in terms of total microbial count was mathematically described through Baranyi's model.

At all storage temperatures the microbial growth rate of OD and PEF-OD samples was significantly reduced compared to untreated samples. At 4°C OD reduced microbial growth rate from 0.236 d-1 to 0.091 d-1, while no significant microbial growth was observed for PEF-OD samples for up to 15 days with simultaneous retention of sensory quality. This resulted in at least three-fold increase of shelf life which for untreated spinach leaves was limited to 6 days (at 4°C). This significant increase in the shelf life of minimally treated spinach leaves allows for its incorporation into composite spinach based RTE chilled products that previously could not be commercialized due the perishability of untreated leaves. Such products are currently being tested as case studies based on the results of this work.

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Emerging processes & hurdles technologies

Poster

Ultrasound-assisted extraction ofn Lupin seeds: influence on phenolic content and antioxidant capacity.

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Lupin seeds represent a potential source of plant-based proteins. However, the nutritional value of the protein extracted from lupin is considerably affected by the presence of polyphenols due to its high ability to associate with proteins during its isolation, which reduces the further digestibility of the protein isolated. This works explores how high power ultrasound-assisted (HPU) extraction of lupine flour could affect the polyphenol content compared to a conventional extraction. Conventional and ultrasonically-assisted extraction experiments (electric power of 180 W) were carried out at 3 and 9 min, two different temperatures (30 and 60 °C) and using both water and an ethanol-water mixture (20:80 v/v) as solvents. Treated flours were freeze-dried for 48 h to reach a final moisture content of ± 7 %. Finally, phenolic content and antioxidant capacity were determined in the treated flour using Total Phenolic Content (TPC) and Ferric Reducing Antioxidant Power (FRAP) methods respectively. HPU application improved the extraction of phenolic compounds compared to conventional process. In general terms, compared to conventional extraction, HPU reduced the phenolic content and antioxidant capacity of the treated flour by 44 and 47%, respectively. This result represents a decrease of approximately 70% of the phenolic content and antioxidant activity of initial lupin flour. The effects of solvent, extraction time and temperature were not significant ($p>0.05$) in HPU experiments.

Further works should elucidate the impact of the ultrasound-assisted extraction not only on the flour but also on the protein solubilization.

Emerging processes & hurdles technologies

Poster

Extraction of anthocyanins from black bean hull with aqueous solutions of deep eutetic solvents by high pressure fluid

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There is currently a great interest in the search for new sources of natural pigments that can, through their consumption, make the diet more functional and healthy. Beans have drawn the attention of researchers because they contain a high amount of bioactive compounds that are beneficial to health. Among these compounds, anthocyanins (present in the peels) stand out, which are antioxidant compounds also responsible for the red, blue, purple, and orange color of many plant species. However, in the process of harvesting and processing beans, a large amount of waste with low commercial value, the “bandinhas”, is generated. This term is popularly used to classify the broken bean grains obtained during the processing of the product. In this context, the purpose of this work was to obtain extracts rich in phenolic compounds and anthocyanins from the industrial residue of beans (Phaseolus vulgaris). For this, deep eutectic solvents (DES) were selected as water modifiers to perform subcritical water extraction (SWE), aiming at selective extraction. To identify an efficient and environmentally friendly solvent, the COSMO-RS model was used, which could predict the affinities of individual anthocyanins on different DES modifiers in water. In this case, the combination of choline chloride and citric acid as water modifiers was the most promising solvent. Temperature, flow and percentage of DES in subcritical water extraction were optimized. The best anthocyanin extraction (3 mg C3G g−1) was obtained at 90 ?C, 5 mL min−1, and 1 % DES, three times more than pure water. The extracts did not show cytotoxicity (normal fibroblastic L929 cells) and showed cytoprotection of L929 cells when subjected to oxidative stress with H_2O_2. Therefore, the implementation of SWE with DES opens up the possibility of increasing extraction efficiency, meeting the requirements of a green and sustainable approach to the application of extracts with anthocyanins as natural dyes.

Emerging processes & hurdles technologies

Poster

Effect of High-Pressure Processing pretreatment on osmotic dehydration of fresh-cut potatoes

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Osmotic dehydration (OD), as a pretreatment step, is used to increase the quality and shelf life of fresh-cut high-moisture content fruits/vegetables. OD potato can be used as a quick-cooking product or as an ingredient in salads/soup mixes. Due to plant tissue structure, OD is inhibited by slow mass transport. Novel non-thermal processing methods suitable for application during or before OD are proposed to enhance mass transfer. High-Pressure Processing (HP) increases plant cell permeability while controlling the activity of endogenous enzymes such as enzymatic browning, via phenolic compounds' oxidation by polyphenol oxidase (PPO) which affects negatively the quality and shelf life of fresh-cut potatoes.
The effect of HP pretreatment on OD of fresh-cut potatoes was studied to optimize processing conditions that accelerate OD and improve product quality.
Fresh-cut potatoes were pretreated at 100-600 MPa for 5-15min at 25-40°C. Determination of enzyme activity (PPO) and objective firmness, were performed. Non- and HP-treated samples were dehydrated using an osmotic solution of glycerol, sodium chloride, calcium chloride, ascorbic acid, sodium sulfite, papain, 4-hexylresorcinol, at a liquid to solid ratio of 1:5, at 35°C. Water loss, solids gain, water activity, sensory properties, and quality indices evolution were determined (0-180 min). WL and SG were modeled using Fick's second law of diffusion.
HP increased the cell permeability and facilitated the diffusion (by increasing the moisture diffusion coefficient) up to 400Mpa, while inducing changes in the structure of raw potato tissue decreasing the firmness and rigidity (up to 30%). OD resulted in high-quality potatoes of lower aw (0.870-0.920) and increased stability. Pre-treated potatoes improved the overall visual quality and reduced browning/discoloration and surface dehydration. PPO activity of pretreated potatoes which was significantly inhibited was modeled as a function of pressure and temperature.
Results confirmed the acceleration of aw reduction by HP and OD of fresh-cut potatoes while improving shelf-life and final product quality via pressure-induced enzymatic browning inhibition.
This research has been co?financed by the European Union – NextGenerationEU and Greek national funds through the National Recovery and Resilience Plan Greece 2.0 under the call RESEARCH - CREATE - INNOVATE [project code T2EΔK-03121 – project acronym: Fresh4ever].

Emerging processes & hurdles technologies

Poster

Alternative Baking of Cereal Dry products considering microwaves and infrared to reduce the baking energy and to enhance the final quality of biscuits

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Traditionally, biscuits baking is done at high temperature resulting in high-energy demand. Such baking condition also yields higher risk of acrylamide formation, which can be magnified by the use of ammonium bicarbonate (leavening agent) due to the presence of ammonium. This presentation addresses new challenges with the objective of developing alternative low-energy processes for baking of biscuits combining microwave (MW) and infrared (IR) heating while enhancing the final nutritional quality, including reduction of acrylamide formation and glycemic index (GI), and sensorial properties of biscuits.
A laminated biscuit has been considered as a model system. The dough was prepared using a combination of ammonium bicarbonate and sodium bicarbonate with sodium acid pyrophosphate as leavening agents. MW-baking at 2.45 GHz was done in a modified domestic microwave cavity equipped with airflow to evacuate moisture and connected to a 200 W solid-state microwave source (SAIREM-France). The proposed process was compared to conventional baking. First results (lab-scale) showed that it was possible to reduce the baking energy by 30% for MW biscuit while obtaining a pale crust colour. The water content of the MW biscuit, which was kept below 5% (wb), was adjusted by controlling the MW power and the baking duration. The texture of the MW biscuit was measured through the 3-point bending test and was comparable to the control biscuit. An investigation on the optimization of the ratio of ammonium bicarbonate to the sum of sodium bicarbonate and sodium acid pyrophosphate has been carried out showing the final volume of the biscuit was impacted by this ratio. The ratio of these leavening agents yielded also an impact on the presence of sodium in the final product, which can negatively affect the taste of biscuits for consumers. Further tests are envisaged to combine MW with IR heating to develop a coloured crust in order to enhance the organoleptic properties of the newly developed biscuit and thus reach consumers' expectations in terms of colour and flavour. Complementary nutritional analyses (glycemic index, acrylamide, sodium content) associated with process optimization in terms of global energy consumption with larger batch of biscuits are also planned.

Poster

Functional characterization of milk powders using Hyperspectral Imaging technique

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Hyperspectral Imaging (HSI) is an emerging technique that incorporates imaging and spectroscopy for acquisition of both spatial and spectral information from an object. Food products characterization using HSI is becoming an alternative to traditional analytical methods. Powdered milk products are valuable food ingredients delivering different functional properties with nutritional advantages. These products undergo quality changes upon exposure of intrinsic and extrinsic factors. In the past decades, the analytical and quality evaluation techniques were so conventional that immediate decisions have not been made to ensure the desired quality on timely basis. Hyperspectral imaging (HSI) can be applied for rapid evaluation of quality characteristics and classification of dairy products in non-invasive manner. Functional properties for characterization of milk powder products including foaming, emulsion, dispersibility, and solubility were measured using conventional techniques following standard analytical procedures. Milk powder functional properties as indicator for product quality and linking milk powder process variables with product quality were correlated with HSI spectral data. Milk powder samples including whey protein isolates and concentrates, milk protein isolates and concentrates, and non-fat dry milk treated at different levels of storage days, humidity, and temperature and were analyzed using a line scan camera in the wavelength range of 367-1048 nm, and pixels' reflection value converted to 0 to 1 scale. Depending on the characteristic parameters, appropriate models were developed to understand the relationships. Based on the chosen experimental plan, HSI is anticipated to provide corresponding characteristic results in response to given treatment conditions. Thus, it will be indicated that HSI will have potential in substituting the labor intensive, time, and chemical consuming analytical methods by advanced techniques for predicting several quality parameters and classifying them in accurate and rapid real time basis.

Poster

From Processing to Product: Utilizing Novel Processing Technology to Produce Plant-Based Protein Yogurt Analogue

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The demand for dairy-free yogurt alternatives based on alternative proteins has been increasing. Yet, many plant-based proteins have limited techno-functional properties, such as poor aqueous solubility, limiting their use and diversification of yogurt alternatives. High-pressure homogenization (HPH) has been suggested as a tool for attenuating some of these technological limitations. This work studied the combination of an alternative plant protein source, potato protein isolate (PPI), as a protein model, with the utilization of HPH to produce a fermented yogurt alternative without adding stabilizers. The utilization of HPH as a pre-processing step (200 MPa and Tin=15°C) increased isolate solubility (from 92.7± 1.1% to 97.5±0.8%) and reduced downstream PPI sedimentation. Before inoculation with lactic acid bacteria, PPI emulsion was subjected to homogenization at pressures ranging from 30-200 MPa. Such a process stabilized the emulsion against separation and allowed sufficient time to form a homogenous gel-like system during fermentation, i.e., no phase separation during fermentation that will result in an inhomogeneous product. Increasing the homogenization pressure reduced the particle size allowing the formation of finer and whiter emulsion with improved physical stability against separation. The hardness was the highest for the yogurt alternatives fermented from the emulsion formed at 200 MPa, suggesting that HPH can significantly assist in attenuating the physical properties of plant-based milk alternatives. The water holding capacity values of the fermented gels were above 80%, which can be an advantage for improving the product shelf life. While many commercial yogurt alternatives contain stabilizers or have relatively low protein content, this suggested process allowed the production of a stabilizer-free yogurt alternative with higher protein content and can be a promising tool for various novel yogurt alternatives.

Emerging processes & hurdles technologies

Poster

ACTIVE GELATIN-BASED FILMS INCORPORATED WITH GUACO LEAVES EXTRACT (Mikania glomerata Sprengel)

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Guaco (*Mikania glomerata* Sprengel) is one of the main native plants used in the Brazilian herbal medicines trade, principally for coughs and flu treatments, whose use is considered safe and effective by the National Health Surveillance Agency. Scientific studies confirm the presence of active substances (phenolic compounds and flavonoids) and the expectorant and bronchodilator medicinal properties in this plant; however, guaco has not been studied for active films or food applications. The aim of this work was to evaluate the effect of the addition of hydroethanolic extract of guaco leaves (*Mikania glomerata* Sprengel) (HEG) on the properties of gelatin-based films. HEG was prepared dispersing 10g of guaco leaves powder in 100g of a solvent with 60% of ethanol in water, under an ultrasound treatment at room temperature for 30min followed by a thermal treatment at 60°C/30min. HEG was added (3 or 9g/100g) in gelatin (6g/100g) and glycerol (1.8g/100g) film-forming solution. Films were prepared by casting technique in polystyrene plates (15cm diameter) and dried at 30°C for 24h. These films were characterized for the physical-chemical properties, antimicrobial and antioxidant activities. Experimental data were analyzed by means of a multifactor analysis of variance and Tukey's test with a 95% significance level using ORIGIN®2022 software. Fourier Transform infrared spectrum (FTIR), microstructure (homogeneous), humidity (14.1-14.4g/100g), water solubility (35.7-36.5g/100g), opacity (0.17-0.20), puncture mechanical properties (13.7-15.7N; 4.1-5.0%), contact angle (79.8-87.9°), and antimicrobial activity (negative) were not affected ($p>0.05$) by the presence of HEG. However, color ($\Delta E^*=3.2\rightarrow4.5\rightarrow8.2$), UV-visible barrier, water vapor permeability ($0.389\rightarrow0.396\rightarrow0.568$g.mm/m².h.kPa), total phenolic compound content ($0.69\rightarrow0.88\rightarrow1.44$mg gallic acid/g), and ferric reducing antioxidant power ($0.49\rightarrow1.05\rightarrow2.34$mg trolox/g) increased ($p<0.05$) with HEG concentration in films. Regarding the tensile mechanical properties, films added of 3g/100g of HEG showed increased ($p<0.05$) resistance ($22.6\rightarrow36.3$MPa) and stiffness ($563\rightarrow934$MPa), without causing a decrease ($p>0.05$) in elongation ($33.4\rightarrow29.8$%). While films added 9g/100g of HEG showed an increase ($p<0.05$) only in resistance ($22.6\rightarrow32.1$MPa), without causing decreased ($p>0.05$) in stiffness ($563\rightarrow700$MPa) or elongation ($33.4\rightarrow38.5$%). Therefore, active films were obtained by the incorporation of the HEG, without prejudice to the other properties, in addition to promoting the strengthening of the mechanical properties of films.

Emerging processes & hurdles technologies

Poster

Impact of macronutrient composition on 3D printability of pea-based food formulations

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The emerging technology of 3D food printing is promising for production of personalized foods. Personalized foods are ideal for individual dietary requirements of a consumer, thereby helping to sustain a healthier diet. However, especially changing the macronutrient composition of foods, i.e. the amount of carbohydrates, proteins and fat, is known to strongly affect the printability—extrudability and buildability—of food formulations. In addition, the amount of added water used for preparing formulations plays an important role. The influences of macronutrients and water are complex and have not been studied systematically before. Therefore, the aim of this study was to investigate the influence of macronutrient composition on printability and rheology using a quantitative experimental design approach. For this, a pea-based model food formulation varying in fibre, starch, and protein content was evaluated in terms of printability namely: (a) extrudability and (b) buildability which was further linked with their rheological properties. A systematic study was conducted by varying one macronutrient at a time. Water content was adapted based on water holding capacity of the various ingredients. From the results, it was found that water holding capacity is a good starting point for systematic formulation of printed foods with various macronutrient composition. Subsequently, it was observed that fibre and protein had a stronger effect on extrusion force and flow point than starch, which may be explained by the microstructure of the formulations. Compositions containing 30-80% fibre, 10-50% protein, and 0-60% starch on dry basis were identified as the ranges within which stable printed samples could be obtained. The knowledge obtained from this research provides a window of operation for successful 3D printing of pea-based formulations and the approach may be used for other printable food formulations as well.

Keywords: Macronutrient composition, personalized foods, 3D food printing

Poster

CHARACTERIZATION OF “CLEAN LABELPAN BREADS MADE WITH NATURAL PRESERVATIVES FROM TAHITI LIME

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The use of essential oils to replace synthetic preservatives in bakery products is an alternative for the current market. Tahiti lime (*Citrus latifolia* Tanaka) essential oil (LEO) has antimicrobial compounds in its composition, especially limonene. Furthermore, supercritical fractionation using CO_2 (SCF) can be used to concentrate these compounds. However, one of the main challenges for using natural preservatives in fermented bakery products such as pan bread is their interference in yeast (*Saccharomyces cerevisiae*) fermentation and product quality. Therefore, the objective of this study was to evaluate the technological characteristics of pan bread made without preservatives, with a synthetic preservative (calcium propionate), and with the natural preservatives LEO and fractionated LEO (FLEO). For this, eight pan bread formulations were elaborated: CONTROL (C), without preservatives; STANDARD (S), with 0.35% calcium propionate; three with LEO and three with FLEO, each at concentrations of 0.30%, 0.60% and 1.20%. The pan breads were evaluated on day 1 for pH, acidity, firmness, specific volume, radial expansion and instrumental color (crumb and crust). Data were submitted to Analysis of Variance (ANOVA), followed by the Tukey test for comparison of means, adopting a significant level of $p<0.05$. Pearson’s correlation test was also applied to verify the relationship of LEO and FLEO concentrations with the parameters pH, acidity, specific volume and bread expansion. Both LEO and FLEO natural preservatives, at the highest concentration (1.20%), increased the pH of breads, and reduced the acidity, specific volume and radial expansion, when compared to the CONTROL and the STANDARD ($p<0.05$), resulting in greater firmness. It was also verified that there was a positive correlation (>0.9) of LEO and FLEO with pH, and a negative correlation (<-46) with acidity, specific volume, and expansion, suggesting interference in yeast fermentation, as the concentration of LEO and FLEO increased. It can be concluded that the use of essential oils to replace synthetic preservatives in bakery products tends to inhibit yeast fermentation and modify the quality of the end product, requiring the use of other techniques, such as microencapsulation, to avoid this negative interference.

Emerging processes & hurdles technologies

Poster

Qualitative and quantitative analysis of erucin and sulforaphane in fresh-cut Eruca sativa treated with Plasma Activated Water (PAW): effect on the enzymatic hydrolysis of the glucosinolates glucoerucin and glucoraphanin

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The project aimed to investigate the effect of Plasma Activated Water (PAW), generated by a high-power atmospheric pressure corona discharge plasma source, on Isothiocyanate in Arugula (Eruca sativa) in rocket salad. Specifically, we explored erucin and sulforaphane content by UHPLC-MS/MS and GC-MS techniques.

PAW was obtained using distilled water from a corona discharge plasma source. Immediately after PAW generation, rocket samples were dipped in PAW for 20 min at room temperature. For each treatment, 20 g of samples were dipped in 400 mL of PAW (product: liquid ratio of 1:20 (w:v)) and kept under constant agitation. PAW-treated samples were compared with untreated ones (UNT).Extraction from freeze-dried rocket leaves were carried out by 60% methanol solution.

Erucin analysis was carried out by GC-MS and identification was confirmed by the comparison of the GC retention time and mass spectrum of both the pure authentic standard (Santa Cruz Biotechnology, Inc., USA). Sulforaphane determination was obtained by liquid chromatography/mass spectrometry analysis (UHPLC/MS) and identified by comparing the mass spectrum and the retention time with that of pure authentic standard (Santa Cruz Biotechnology, Inc., USA).

The relative abundance of erucin peak detected in the scan mode in PAW-20 rocket salad extract was about 20% lower than that detected in the UT sample.

Sulforaphane (precursor ion m/z 178.100) was identified in both extracts. Its identification was confirmed by comparing the mass spectrum and the retention time with that of pure authentic standards (Santa Cruz Biotechnology, Inc., USA). The method of the calibration curve was adopted for quantification by using sulforaphane calibration solutions at ten concentration levels ranging between 0.01-10 µg/mL. Quantification results revealed a significant lower concentration (t-test, $p<0.05$) of sulforaphane in PAW-20 extract (134±2 µmol/L) than in UT extract (365 ±7 µmol/L).

Interestingly, previous results indicated an increase of glucosinolate (glucoraphanin and glucoerucin) relative percentages (around 44 and 50%, respectively) in PAW-20 extracts compared to the UT extract. Since glucosinolates were the precursors of the bioactive compounds sulforaphene and erucin, these results suggested that PAW could affect the enzymatic hydrolysis of glucosinolates into their corresponded products probably by inhibiting the myrosinase reaction.

Poster

EFFECTS OF LOW INTENSITY PULSED ELECTRIC FIELDS IN TECHNO-FUNCTIONAL PROPERTIES OF CHICKPEA (Cicer arietinum L) FLOUR

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Chickpea is a legume recognized for its high nutritional value whit a protein content around 19 – 22g/100g (d.b.), being constituted by globulins, albumins and glutenins. These proteins are characterized by having good techno-functional properties such as water (WAC) and oil (OAC) absorption capacity, emulsifying, foaming and gelling. Therefore, chickpeas represent a potential source for the development of high-protein ingredients. Depending on treatment conditions, protein techno-functional properties could be improved. Recently, pulsed electric fields (PEF) habe been applied to enhance protein techno-functionality of different sources of plant-protein concentrates and isolates, such as soybean, mung bean, peas, rice, and gluten, among others, with interesting results. The aim of this research was to evaluate the effects of moderate intensity PEF (E: 1, 2, 3 kV/cm during 750, 2250 and 3300 µs) on techno-functional properties (WAC, OAC, emulsifying, foaming and gelling) of chickpea flour. PEF processes were performed in an EPULSUS®-LPM1A-10-System using mono-polar square wave pulses at 20 Hz. 100 g of soaked chickpeas (15 h) suspended in 300 ml of water were treated in triplicate in a parallel chamber with stainless steel electrodes. PEF-treated chickpeas were subsequently dried, obtaining a drying curve for each sample. Dried samples were grounded to obtain the flour, which was subsequently analyzed, having flour from untreated chickpeas as reference. Results indicated that drying time of PEF-treated chickpeas significantly decreased regarding the untreated sample. Likewise, flour from chickpeas treated at 1 kV/cm showed greater WAC (1.93, 1.93, 2.07g/g during 750, 2250 and 300 µs, respectively) and similar OAC (0.92, 0.93, 0.89g/g during 750, 2250 and 300 µs, respectively) than the control chickpea flour (WAC:1.44g/g and OAC:0.82g/g). PEF process at different E and treatment time caused a decrease in the foaming capacity (27 – 35%) of chickpea flours regarding to the control (43%), while emulsifying capacity did not present significant differences. Likewise, flour from PEF-treated chickpea (1 kV/cm, 220 µs) showed the greatest gelling capacity. PEF treatment at low intensity (1 kV/cm) represents a potential alternative to improve some techno-functional properties, such as WAC, OAC and gelling, of chickpea flour that could be used to develop high-protein ingredients.

Poster

Pulsed Electric Fields for white wines production: Investigation on sensory and physico-chemical characteristics of Arinto and Moscatel wines

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Pulsed electric field (PEF) was studied at a pilot scale winery for the production of white wines from Arinto and Moscatel de Setúbal varieties. The PEF treatment was initially applied to the grapes before pressing for juice extraction, and then once again to the finished wines before bottling, for wine stabilization. The effects of both PEF treatments on the sensory and physico-chemical parameters of the wines were assessed. Sensory triangle tests confirmed the absence of a significant impact on colour, odour and taste of wines with both PEF treatments applied during vinification. With respect to physico-chemical parameters, pH, total acidity, and CIE L* colour coordinate were not affected by PEF. The PEF extraction method caused an increase in the total phenols, non-flavonoid phenols, turbidity, and CIE b* colour parameter in the finished wines. Overall, the sensory also revealed that the wines submitted to PEF treatments were acceptable in terms of colour, smell, and taste. This study demonstrated the efficient application of PEF at a pilot scale level, with retention of the original quality properties of both white wines.
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Emerging processes & hurdles technologies

Poster

Investigating the efficacy of combined treatments of ultrasound and antimicrobial extract for the inactivation on food pathogens on ready-to-eat salad leaves

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The consumption of ready-to-eat pre-washed salad leaves has been increasing due to health benefits and convenience. However, current processing methods, such as water washing, are not fully effective to eliminate pathogenic bacteria, as demonstrated by recent outbreaks linked to the consumption of such foods. It is therefore necessary to investigate other technologies to ensure the microbiological safety of these products.

Ultrasound is a novel non-thermal technology of interest. As it is a milder than traditional thermal technologies, ultrasound may be used to process heat-sensitive fresh produce i.e., salad leaves. However, its mild nature may instead represent a sublethal stress, leading to stress adaptation, post-treatment survival, and the potential for antimicrobial resistance development in pathogens. Previous studies indicate that combining ultrasound with other decontamination techniques as a hurdle technology can be effective to increase the antimicrobial efficacy; indeed, it could be combined easily with water washing of fresh produce. Furthermore, antimicrobial extracts from pomegranate peels have been shown to inhibit the growth of some pathogenic bacteria and utilise a by-product from food manufacturing. The combination of pomegranate extract and ultrasound has been investigated in fruit juice but has not yet been studied on salad leaves. As such, this work presents a systematic investigation into the efficacy of ultrasound in combination with pomegranate peel extract for microbial inactivation.

Ultrasound was applied at a range of frequencies (44 - 1000 kHz) either alone or in combination with pomegranate peel extract to salad leaves inoculated with L. monocytogenes or E. coli. The multi-frequency analysis was conducted in a reactor vessel with interchangeable transducers, allowing for consistency in experimental set-up and therefore a systematic approach to identify inactivation mechanisms. The efficacy and mechanisms of inactivation were found to depend on parameters including the applied frequency, applied power, the combination of treatments, and the microbial species. The effect of these inactivation treatments on the organoleptic properties and structure of salad leaves was also investigated.

This work indicates that water washing of salad leaves may be enhanced by the integration of pomegranate extract and ultrasound treatment, ensuring microbiological safety while maintaining structural properties.

Poster

Dry heat treatment of wheat flour by MICRO-WAVE; application to desinfectation, flour correction (alpha-amylase activity) and functional flour

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The heat treatment of dry flours has various applications. At low temperatures (LT<100°C), e.g. disinsectisation, correction of amylase activity (fall time) are targeted while maintaining gluten functionality. At high temperature (HT ~110-150°C), proteins are affected (gluten, starch's surface proteins) and functional flours are obtained (equivalent to chlorination) which can be used with partial substitution of wheat flour in bread applications to enhance texture or with full substitution in fine bakery wares applications such as sponge cake to gain in volume and texture. A comparison of LT (55-65-75-85-95°C) and HT (110-130-150°C) treatment with conventional and microwave (MW) heating was carried out on a continuous semi-industrial tunnel (SAIREM-France). Bread and sponge cake trials as well as various functionality tests used to characterize flours (Alveo, Farino, SRC etc) confirmed the interest of microwaves for these applications (faster process) while underlining the temperature thresholds not to be exceeded. The bread making quality was affected in terms of volume for treatment above 75°C; such treatment allowed full inactivation of Tribolium castaneum insects (treatment made on a contaminated flour). For HT processes, RVA parameters exhibited higher peak viscosity for MW HT treatment compared to conventional in particular at 110 and 130°C. The MW HT treated starches had a higher water content than conventional process (3 to 4% db), resulting in a lower energy consumption for MW treatment. As a conclusion, MW heat treatment applied to starches (under the form of wheat flour) offers promising perspectives in terms of efficiency and energy consumption.

Poster

Impact of innovative processes on the nutritional and structural quality of Mediterranean flat bread

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Bread is a staple food, often consumed daily in particular in the Mediterranean area in the case of flat-bread. The high consumption of bread may address health issues. The glycaemic index (GI) of flat-bread has been minimally investigated so far in the existing literature. High GI foods may contribute to several diseases linked to metabolic syndrome. Another facet of flat-bread concerns is the high energy demand required for baking (300-500°C). The objective of this project is to unravel the links between baking conditions and GI, in order to reduce the GI and to better understand the link between GI and starch status. This approach will provide insight in the impact of the baking conditions on bread quality (nutritional and structure) in link with energy demand. In order to address these issues, the impact of the process for gluten flat-bread has been investigated considering partial baking as an alternative baking process. The reference baking of flat bread was carried out at 350°C for 1 min, whereas the partial baking was done at 350°C for 30 sec. The part baked breads were frozen and stored at -18°C. The final thawing-baking of the part-baked flat-bread was done in a toaster before consumption. The texture, water content and amylopectin retrogradation of the control and part-baked bread were monitored during storage at room temperature to characterise the impact of the process on the staling of flat breads. The nutritional aspect was evaluated through a dual approach combining the determination of the GI (in vitro method) and the amount of non-gelatinized starch. Indeed, due to the high heating rate observed during baking, starch undergoes a partial gelatinisation resulting in a contribution to the reduction of GI. The impact of the partial baking process on the energy demand depends on the preheating energy and on the energy during baking. In the case of flat-bread, the energy for preheating of the oven is dominating showing the importance of the mode of baking. These results allow a better understanding of the impact of the baking process in the case of flat bread baking.

Emerging processes & hurdles technologies

Poster

Optimization of pulsed electric field parameters to improve the technological properties and increase the soluble dietary fiber content of carrot pomace through response surface methodology

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Huge amounts of vegetable wastes are generated from juice production. Carrot pomace is an excellent source of dietary fiber (DF). However, the incorporation into food products is difficult because of the high content of insoluble dietary fiber (IDF). Consequently, there is a great interest in modifying the structure for increasing the content of soluble dietary fiber (SDF) and improving the technological properties. Pulsed electric fields (PEF) is a non-thermal processing technology, which can modify the structure and properties of different biomolecules. This study focuses on establishing the optimal parameters for PEF treatments applied with the aim of improving the technological properties and increasing the SDF content of carrot pomace.

For this, a central composite design with 2 independent factors has been used: number of pulses (n) and electric field strength (E = kV/cm). For each factor, extreme lower and upper values were identified (E = 5 - 7 kV/cm; n = 5 - 125). The response variables analyzed were the water retention (WRC), oil retention (ORC), cation exchange (CEC), water swelling (WSC), stabilizing (SC) and emulsifying capacity (EC), solubility, and DF content (SDF and IDF). The validity of the experimental design was confirmed by ANOVA and the optimal conditions were established by response surface methodology.

The high determination coefficients (R2), the non-significant lack of fit ($p>0.05$), and the high F-values indicate that the models were significant ($p<0.001$) and could be used to predict the response. Based on the models, conditions were obtained leading to optimal technological properties and SDF content. Carrot pomace treated at 7 kV/cm and 75 pulses showed higher WRC (61.6%), SDF content (27.4%), ORC (10.41%), CEC (9.6%), WSC (10.4%), SC (11.7%), EC (13.7%) and solubility (36.8%), and lower IDF content (15.5%), compared to untreated pomace.

Therefore, the treatment with PEF under optimal conditions has proven to be an effective method for improving the technological properties and increasing the SDF content of carrot pomace, thus facilitating its incorporation as a functional ingredient to formulated foods.

Poster

Ultrasound applications for more efficient food processes

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Ultrasound has been used in a variety of food processing procedures, both for research and commercial applications. This technology has generated considerable interest due to its environmental friendliness, improved throughput, lower prices, streamlined operations, and better final product quality. Ultrasound is composed of sonic waves with frequencies higher than human ear audible sound. Power ultrasound uses lower frequencies than medical applications. The sonication generates bubbles in the liquid food as the wave energy propagates, a phenomenon known as acoustic cavitation. The ultrasound unit consists of a generator which converts electricity into high frequency alternating current and a transducer for converting the current into mechanical vibrations. The main objective of this study was to review the most recent ultrasonic assisted food processing applications and equipments. The design of ultrasound systems for liquid foods cavitation included beverages pasteurisation, filtration, liquid extraction, foaming, and defoaming unit operations. Ultrasound configurations for cutting, freezing, drying, and brining/pickling of solid food processes were also covered.
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Emerging processes & hurdles technologies

Poster

Optimizing the extraction of isoflavones from okara using a choline chloride-based deep eutectic solvent

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Okara is a solid residue generated after obtaining soy extract and is rich in phytochemicals such as phenolic acids and, mainly, isoflavones. These compounds are phenolic compounds that are associated with several health effects, mainly in the relief of menopausal symptoms and prevention of breast and prostate cancer. This makes okara an interesting residue for extraction of antioxidants and application in products that promote human well-being. Aiming at the best use of this residue, in this work six soy isoflavones were extracted: daidzein, genistein, glycitein, daidzin, genistin, and glycitin. A deep eutectic solvent (DES) consisting of choline chloride (ChCl) and acetic acid (AA) (ChCl:AA, 1:2) was used for extraction. All compounds were quantified by UHPLC-MS. Initially, a screening of the variables temperature (°C), % water, solid-liquid ratio (mg/mL) and stirring speed (rpm) was performed applying a fractional design (24-1) followed by optimization applying a central composite rotational design (CCRD) (2^2 + 2 axial points+ 4 repetitions at the center point). Total isoflavone content was used as the response variable. From the screening, statistically significant effects ($p<0.05$) on isoflavone extraction were observed for the variables temperature and % water in DES and were therefore used for optimization. The effect of temperature was evaluated from 40-70 °C and that of % water from 40-100%. From the CCRD analysis only the water content showed significant effect at the levels studied, being the maximum extraction at 40°C, 500 rpm, liquid solid ratio of 10 mg/mL and 61.5 % water. In this condition, 116.61 ug of daidzein/g; 151.31 ug of genistein/g; 27.98 ug of glycitein/g; 52.0 ug of daidzin/g; 74.74 ug of genistin/g; and 28.26 ug of glycitin/g were extracted; totaling 450.9 ug of total isoflavones/g of dried okara. Thus, in this work, it was possible to maximize the extraction of isoflavones from okara using DES, making this mixture an interesting alternative for isoflavone extraction, replacing conventional solvents such as ethanol and methanol. And, an alternative to better use this residue, generating products with high added value.

Emerging processes & hurdles technologies

Poster

Application of frozen plasma-activated water to sanitize and precool fresh produce during postharvest handling process

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Converting plasma-activated water (PAW) to frozen PAW (FPAW) imparts additional advantages, for it can simultaneously conduct washing, pre-cooling, and decontaminating when incorporated with water. This study investigates the efficacy of FPAW undergoing pH adjustment on decontaminating *E. coli* and *S. aureus* inoculated on okra and strawberries surfaces. The effects of two different types of PAW (fresh and FPAW) dissolved in water and immersion time (0, 10, 15, and 20 min) on PAW efficacy in combination with the surface properties of okra and strawberries are investigated. Even though the bacterial reduction achieved by this study was generally lower than the treatment applied to planktonic *E. coli* and *S. aureus*, the efficacy of FPAW was not entirely eliminated by the surface roughness of the treated product and other intertwining factors. Log reductions >2.5 and >1.0 for *E. coli* and *S. aureus* were achieved, respectively, indicate that pH-adjusted-FPAW has the potential to be applied in the postharvest treatment of fresh produce. In addition, the treatment applied did not significantly affect the physical quality of the product; in fact, the precooling effects of frozen PAW prevent the chilling injury on okra stored at 4.5 ± 0.5 °C for 10 days.

Emerging processes & hurdles technologies

Poster

Comparison between meat analogues developed using high-moisture extrusion processing and protein elongation method

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Meat analogues exhibit anisotropic (e.g., layered or fibrous) structures that give an appearance and taste-texture sensation similar to muscle meats. Meat analogues can be produced by various methods such as extrusion, freeze structuring, electrospinning, in-vitro animal cell culture, and shear cell technology. Out of these technologies, high-moisture extrusion processing has been the preferred and widely used technique of choice, notably by large-scale Asian manufacturers, and especially among Western manufacturers. This is because of its scalability and the consistent quality of the textured products produced. Our research team recently developed a method to produce such meat analogues, which is more affordable and uses less sophisticated equipment, known as protein elongation. This technique involves cutting protein dough into smaller fragments, followed by stretching and pulling these protein fragments, resulting in anisotropic structures resembling meat fibres. The study compares the physicochemical, textural and structural properties of meat analogues (soy protein concentrate (SPC) and wheat gluten (WG) at the ratio of 40:60 or 60:40 %w/w dry protein basis) made from extrusion processing and protein elongation method. The protein and moisture content of the meat analogues showed no significant differences, as the formulation used in the two processes was similar. Interestingly, the pH levels of the meat analogues were different. The extruded meat analogues were found to be harder, springier and chewier than the protein-elongated meat analogues. Extruded meat analogues demonstrated more aligned macrostructures upon visual examination, while protein-elongated meat analogues at SPC: WG ratio of 60:40 did not exhibit any fibrous network. Scanning electron microscopy analysis showed that fibrous structures were more prominent in extruded meat analogues than in protein-elongated meat analogues. It was concluded that the protein elongation method could be an alternative approach to rearranging protein fibres to produce textures and structures like meats, other than extrusion processing. This allows smaller-scale manufacturers to contribute to the market with more variety of plant-based food products in the future.

Emerging processes & hurdles technologies

Poster

A novel approach for the extraction, chemical characterization of carotenoids and lipids from Chlorella vulgaris

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Over the years, there has been a strong interest in the downstream processing of microalgae for the extraction of lipids and pigments as it is widely used in food formulations, cosmetics, and pharmaceuticals due to its rich fatty acid profile, and bioactive properties. The purpose of this study was to investigate the performance of novel extraction techniques for the recovery of pigmented lipids from *Chlorella vulgaris (C.v)*. The use of lipids obtained from *C.v* has been described as a promising alternative to fish oil (FO) due to the sufficient level of omega-3 fatty acid. Besides, the consumption of microalgae oil (MAO) ensures the intake of carotenoids, which gives MAO a nutritional benefit compared to FO.
Initially, sixteen novel extraction strategies were investigated for the extraction. Based on the extraction yield of carotenoids and lipids, six strategies (i.e., ultrasound-assisted extraction (UAE=1), pulsed electric field (PFAE=1), microwave-assisted extraction (MAE=1), ultrasound-microwave assisted extraction (UMAE=1), conventional-assisted extraction (CAE=1) and a control (CN=1)) were selected and explored further for fatty acid and carotenoid profiling, which was carried out using a gas chromatographic techniques.
The highest extraction of lipids (0.09 g/ g DW C.v) and carotenoids (4.5 µg/g DW C.v) was measured in samples treated with UAE (frequency-20 kHz; amplitude-100 %; time-10 min; temp four °C) compared to CAE where the level of lipids (0.02 g/ g DW C.v) and carotenoids (0.3 µg/g DW C.v) were significantly ($P < 0.0001$) low. The primary fatty acids identified were C16:0, C18:0, C18:1n9c, C18:2n6c, and C18:3n3.
Hence, the present study demonstrates a promising alternative to conventional lipid extraction from microalgae. The quantitative information on fatty acids and carotenoids can provide valuable data for process design at pilot and industrial scales.

Poster

Use of the adsorption and coating techniques to increase the load of polyphenols from pomegranate extract encapsulated by ionotropic gelation

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The instability of polyphenols under certain processing conditions such pH and temperature or presence of oxygen and metal ions impacts their functionality and nutritional value and represents the greater challenge for their application in food matrices. In this work, ionotropic gelation was employed to produce beads of pectin (P) for encapsulation of pomegranate extract (PE), aiming to improve its stability, retention and to control its release. Several strategies were tested to improve the retention of the hydrophilic extract: the addition of starch (PS) as a filler - mixtures of P and (PS) were realized in previously defined combinations, two methodologies for PE entrapment: the mixture of PE with the biopolymer solution (L) before produce the beads, and by adsorption (AD) of PE into blank pectin-starch beads, and finally, the complexation of the bead's surface by chitosan (1% w/w). The total phenolic content (TPC) and release percentage in water were evaluated as indicators of retention. The L-beads showed TPC about 3 times lower (P: 923.09 ± 29.90 and PS: 994.23 ± 34.80 mg of gallic acid equivalent/100g sample) than AD beads (P: 2541.69 ± 74.77 and PS: 2960 ± 26.92mg of gallic acid equivalent/100g sample). In the coating process, there was a loss of phenolics in the chitosan solution and the TPC of all particles was reduced by about 30-40% for both formulations. But the coating helped to reduce the release from PS beads. A reduction of about 8 and 20% was observed for L-beads (72.99% ± 2.65 to 66.90% ± 3.28) and for AD beads (84.81% ± 6.58 to 68.57 ± 4.89), respectively. However, P beads showed a higher percentage of release when coated. In general, the starch favored greater retention of phenolics and the coating provided a reduction in the release rate for these formulations. New tests with process adjustments during the coating can minimize losses, making the encapsulation technique studied viable for the production of foods enriched with polyphenols.

Poster

From'Innov : a new technology to obtain aroma in solubilized soft-cheese

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The dairy platform of the STLO, Rennes, developed an innovative technology and more sustainable cheese making process (INRAE patent, From'Innov, WO2016108024). This technology consists of mixing a texture matrix obtained by ultrafiltration with one or more aromatic matrix. The latter is innovative: it allows obtaining a maximum of aroma in a short time, less than a few days. The principle is to grow each of microorganisms in an optimized middle with essential nutrients, optimal pH and temperature, and O2 if necessary. After adjusting the pH and temperature of the mix, we proceed with the coagulation then the molding, and the next day the demolding. The cheese is ready and contains the expected aromas. It needs five days to obtaining a soft-cheese with surface flora such as Penicillium and/or Geotrichum.
We used this vector to define the consumer's level of acceptability in view of a breakthrough technology.
In this study, a commercial cheese (control product), representative of solubilized soft-cheeses, and two From'Innov cheeses (one close to control and the other more with more character) were studied. The acceptability and the main sensory properties of these three cheeses were evaluated by a panel of 142 consumers. The objective was to determine the hedonic appreciation of From'Innov cheeses, compared to that of commercial cheese, and to determine the sensory properties enhancing or penalizing the appreciation of different cheeses.
The results showed that the hedonic appreciation of From'Innov cheese with character, although lower than that of commercial cheese, is satisfactory (5.6/10), despite a ripening time four times shorter. In addition, the intensity of the fruity notes and the character of this From'Innov cheese were judged to be close to ideal, whereas these two characteristics were judged to be insufficiently intense in commercial cheese. Finally, despite a lower salt (-20%) and fat (10%) content, the intensity of saltiness and fat of From'Innov cheese with character was judged to be close to ideal, very close to that of commercial cheese.
The perspective of this study is to know whether our innovative technology will have a place in the current market and for which products, for whom?

Emerging processes & hurdles technologies

Poster

Study of the impact of yeast starter use on microbial population dynamics during the fermentation of cocoa beans, and of its ultimate impact on cocoa composition and flavor

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Cocoa quality derives strongly from its flavor. Cocoa flavor may be seen as the result of the biochemical reactions that take place during the cultivation, harvest and post-harvest processing of the cocoa beans. Both, volatile and non-volatile compounds contribute to the final flavor perception of cocoa. Fermentation has arguably the most significant impact on the formation of volatiles (mainly alcohols, esters, and carboxylic acids), and their precursors. Some of these precursors and intermediates will then be further transformed during roasting by means of Maillard reactions and Strecker degradation. Fermentation of cocoa beans involves an initial anaerobic phase (driven by yeasts and lactic acid bacteria), followed by an aerobic phase (where acetic acid bacteria are predominant). This work focused on the study of the impact of fermentation time and of the use of a commercial yeast starter culture on the compositional differences in the taxonomy of fungal and bacterial microbiota present in the cocoa bean and pulp mass throughout fermentation, as well as on the final volatile composition of the dry beans obtained therefrom. This microbial composition would thus influence greatly the final volatile composition of the beans, which translates into differences in the perceived flavor profiles of the products obtained thereof. Large-scale fermentation trials of CCN-51 cocoa beans were carried out in wooden boxes (550kg) in Ecuador in February 2022. Two different fermentation techniques were carried out: one spontaneous and another one inoculated with a commercially available strain of Saccharomyces cerevisiae. Beans with pulp were collected every 24h throughout the entire fermentation process for the fungal and bacterial DNA to be later extracted, amplified and sequenced following a metabarcoding approach, using the pertinent ITS and ADNr 16S taxonomy assignment databases. Likewise, beans were collected and dried after 4, 5, 6, and 7 days. A SPME-HS extraction (using a DVB/CAR/PDMS fiber) and GC/MS analysis of volatiles compounds was performed on dried raw beans. This allowed to showcase the impact of time and of the addition of yeasts during fermentation on the composition of microbial communities and on the flavor potential of the fermented cocoa.

Emerging processes & hurdles technologies

Poster

Chitin-deacetylase production by microorganisms: a key step towards a sustainable production of bioactive chitooligosaccharides from marine shell wastes

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The marine processing industry generates more than 20 million tonnes/year of waste. This highly perishable material can represent up to 45% of shellfish weight, including heads, thorax, claws, and shells. Once extracted from proteins and minerals present in the shells, during two processes called demineralisation and deproteinisation, chitin can be chemically converted into chitosan (deacetylation), which in turn can be depolymerized into fragments of lower molecular weight, called chitooligosaccharides (COS). COS are a group of bioactive molecules with many applications in food, pharmaceutical and medical industries. Among the four steps needed to transform chitin from marine shells into COS, deacetylation is considered the most challenging. Chitin deacetylases (CDAs) are still too expensive commercially and their biotechnological production is still limited due to low extracellular production by most microorganisms. Although many efforts have been made in the last two decades, this is considered a key step in obtaining high-quality COS that exhibit specific biological properties. We tested Penicillium chrysogenum (ATCC 10106) as a biotechnological producer of intra and extracellular CDA. For this, static solid-state fermentation (SSF) using wheat bran and static liquid fermentation were tested at lab scale (200 mL), for 10 days. The extraction of the extracellular enzyme was done by mixing the fermentation substrate with buffer solution, followed by centrifugation, while the intracellular enzyme was recovered by the collection of spores followed by one of two methods: (1) beads milling at a mass ratio of 1:2 (spores:glass beads) or (2) manual grinding followed by US bath for 15 min. Extracted solutions were tested for CDA enzymatic activity determined by the 4-nitroacetanilide reaction. Appropriate inactivated enzyme blanks were tested for each condition. Although extracellular production of CDA was not detected by both methods (SSF and liquid), intracellular production of CDA by P. chrysogenum was high for both extraction methods, but beads milling resulted in a 2-fold higher enzymatic activity (237.9 U/g of protein). Our results indicate that P. chrysogenum is an interesting producer of intracellular CDA. Chitin deacetylation using P. chrysogenum's enzyme can produce COS from a high pollutant waste, with the quality required to express COS health-promoting properties.

ICEF14 June 20-23, 2023 LA CITÉ DES CONGRÈS NANTES - FRANCE

Emerging processes & hurdles technologies

Poster

Pea protein extraction assisted by lactic acid fermentation: Impact on protein profile

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The growing interest of the agri-food industry in plant proteins makes it necessary the obtention of new protein fractions with differentiated characteristics and technological properties. Using new extraction methods may allow the obtention of protein fractions with particular properties. In this study the alkaline solubilization/isoelectric precipitation method has been modified by using fermentation. In fact, the reduction of pH to reach the isoelectric point of proteins has been achieved during fermentation by lactic acid bacteria instead of mineral acid addition. Two lactic acid bacteria strains (Streptococcous thermophilus and Lactiplantibacillus plantarum) have been used, either alone or in co-culture, and the results have been compared with the conventional acidification. The extraction method has been analysed in terms of protein yield. The albumin rich- and globulin rich-fractions have been characterized in terms of polypeptide profile by SDS-page and SEC-HPLC. Extraction assisted by fermentation has led to the increase in the total protein content of albumin fraction, which means the solubility of pea protein increased. This can be explained by the proteolytic activity of bacteria. That could be also the reason why viciline subunits have been found in the electrophoresis pattern of albumin rich-fraction of the fermented samples. The analysis of the albumin-rich fractionby size exclusion chromatography (SEC-HPLC) has also shown higher amounts of peptides (<10kDa) in samples fermented with co-culture compared to the monoculture and conventional acidification. Clearly the proteolytic action of microbial enzymes plays a key role in the protein composition of obtained fractions. The use of acidifying bacteria during vegetal protein extraction will allow obtaining protein fractions with differentiated protein characteristics. It would be interesting to analyse the effect of fermentation on the antinutritional factors of legumes in order to valorise albumin-rich fraction.

Emerging processes & hurdles technologies

Poster

Computer simulation of the maltose production in sweet potato during microwave cooking

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Sweet potatoes have the characteristic of becoming sweeter when they are heated, basically due to starch becoming gelatinized, and β-amylase hydrolyzes the gelatinized starch resulting in the production of maltose, the main component of sweetness. Nowadays, the use of microwave (MW) cooking at home is a popular practice which in parallel is challenging because its characteristic high heating rate can affect the intrinsic chemical changes of sweet potatoes due to heat. To clarify this phenomena, experimental and simulated approaches for the MW cooking of sweet potatoes were evaluated.

The dielectric properties of sweet potatoes during MW heating were measured from 20 to 90 ? at 2450 MHz. A three-dimensional (3D) geometric model based on the actual structure and size of the MW flatbed oven and sample was constructed. Two commercial software packages, which are based on the finite element method, were used for the calculation by coupling the analysis of electromagnetic fields and heat transfer. The MW cooking of sweet potatoes was examined and the maltose production process was analyzed by simulation. A new kinetic model of maltose production based on the β-amylolysis limit was proposed. The kinetic parameters of multi-reaction gelatinization, saccharification, and β-amylase inactivation were determined successfully by a combination of simulation and experimental approaches.

The dielectric constant decreased with increasing temperature; whereas, the dielectric loss factor values were similar at 20–60 °C. However, at 60–90 °C, the values decreased sharply. The temperature change inside the sweet potato (temperature profiles and cross-section distributions) was compared with the experimental results. The simulated temperature results agree well to the measured results. From the simulated temperature profiles and kinetic parameters, the change in non-gelatinized and gelatinized starch, the active β-amylase, and the maltose during cooking were simulated. Although the simulated maltose production occurs at positions where the temperature rises, at early stages, at later stages maltose production is suppressed by the inactivation of β-amylase. Results could be used as tools to control the sweetness of sweet potatoes for the optimal design of products and cooking methods by MW technology.

Poster

Mechanisms in controlling the enzymatic browning of strawberry nectar

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The polyphenol oxidases (PPOs) responsible for enzymatic browning have a substantial impact on strawberry nectars' colour. The action of PPOs has been inhibited using physical and chemical techniques. Chemical inhibitors can be classified as antioxidants, reducing agents, chelating agents, acidulants, or mixed-type PPO inhibitors according to how they work. Physical techniques work by heating or applying high pressure to the enzyme, denaturing it, and rendering it inactive. In this study, the effects of 5 chemical and 2 physical PPO inhibitors on strawberry nectar were examined. The remaining activity (RA) of PPO was assessed, and the total colour difference (dE) and CIE Lab parameters for lightness (*L) and redness (*a) were utilized to estimate colour changes. A Minolta colorimeter was used to measure colours. These elements led to the identification of the most efficient strategy for preventing the enzymatic browning of strawberry nectar. However, safety and cost-efficiency have been key considerations in controlling enzymatic browning. Furthermore, consumer demands call for further attention to natural sources, health advantages, and sustainability.

Emerging processes & hurdles technologies

Poster

Control of Listeria monocytogenes present on surfaces by managing the Relative Humidity of the air

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Cleaning and disinfection operations are essential to control hygiene in the food industry. However, these operations have environmental impacts because they require large amounts of water, biocides and energy. The drying of the food processing rooms is an essential prerequisite for restarting the production lines once the cleaning and disinfection stages have been completed. Since the processing rooms are generally equipped with systems allowing the management of the Relative Humidity of the air (RH), the control of the RH appeared as an interesting approach to fight against pathogens present on the different surfaces (floors, walls, machine surfaces).

The main objective of this study was to propose a complementary approach to cleaning and disinfection procedures, used daily as a control measure on the surfaces of food processing rooms, via the implementation of a drying process to reduce the environmental impacts of these procedures. *Listeria monocytogenes* was used as a model pathogen.

Thirty strains of different origin were subjected to drying at 75% RH for 3 h at 25°C. The resistance of strains to drying was not explained by their origin, virulence and genotype. Four strains were selected based on their resistance and virulence. They were exposed to RH levels from 75% to 11% for 30 min to 960 min. Cultivability measurements mainly showed that drying at 68% RH proved to be potentially interesting to effectively destroy *L. monocytogenes*. Additional results have shown that the solution in which the bacteria are dried and then rehydrated influenced the cultivability measured in fine. The application of dehydration and rehydration cycles has shown the effectiveness of this approach to optimize the bacterial destruction. The different approaches to study the effects of drying on the physiology (flow cytometry and forced atomic microscopy) of *L. monocytogenes* have shown that membrane permeability and the cell wall integrity were significantly altered during drying at 68% RH followed by a rapid rehydration phase.

This work showed that RH offers an interesting potential to fight against pathogens and more particularly against *L. monocytogenes* present on surfaces. The cell wall seemed to be an interesting target to optimize this approach.

Emerging processes & hurdles technologies

Poster

Method of quantitative antimicrobial activity measurement of antimicrobial substances

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As a method of measuring the concentration of bacteria, a spectrophotometer measurement method and a plate counting method are used. However, the spectrophotometer measurement method is not suitable for measuring the concentration of living cells because it measures the number of dead cells as a method using the increase in turbidity of the culture medium as the number of cells increases. Therefore, the plate counting method is used to measure live cell. The plate counting method is a method of counting the number of colonies formed by the proliferation of a strain. However, this method has a limitation in that it requires the use of a low concentration strain suspension for quantitative measurement. In this study, we proposed a measurement method using Image J for effective quantitative measurement of high-concentration bacteria. In addition, we intended to quantitatively measure the antibacterial activity of the antimicrobial film through the Image J measurement method. For quantitative measurement of high-concentration bacteria, strains of 101, 104, and 107 CFU/mL were smeared on eosin methylene blue ager (EMB) medium, and RSM of the antimicrobial films were performed using the Image J program. For the treatment method using Image J, only the medium was selected as the oval type, and the petri dish side and background were removed as a clear outside type. The green color was then separated through a split channel type and measured the area where the bacteria grew. As a result, the area of bacteria could be measured using Image J, and colonies and non-colonies could be distinguished and quantitatively measured. It was confirmed that the higher the concentration of the antimicrobial substance in the antimicrobial film, the better the antimicrobial activity, and there was no difference according to the incubation time. Through this study, it was confirmed that high concentration of bacteria can be quantitatively measured by measuring the area ratio where colonies are formed, and it was confirmed that the antimicrobial activity of antimicrobial substance can be quantitatively measured.

Poster

Joint effect of heat, pH and grape extract on Bacillus cereus spores survival in a precooked rice matrix

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Rice is one of the most important cereals in the worldwide and it is the staple food in many countries; however, its high carbohydrate content makes it an excellent medium to *Bacillus cereus* growth. Its spores are resistant to traditional cooking treatments and if there is no adequate post-cooking storage, it can germinate and growth representing a high risk to consumer health. Natural antimicrobials have gained popularity as hurdle technologies when combined with heat. The objective of this study was to determine the antimicrobial activity of grape extract against *B. cereus* spores in a cooked rice matrix. The study was carried out by comparing a control sample and a sample with grape extract, in both cases, the solutions were adjusted to different pH levels (4.5-5.5-6.5) and were treated at different temperatures including those used in conventional cooking process of rice (90, 95, 100 and 105ºC). The survivor data obtained were fitted to the Bigelow and Weibull models; it was found that the best fitting model was the Weibull function distribution. From that, the values of *a* and *b* parameters were determined. With these data, an ANOVA analysis of variance was performed and showed that the grape extract had an antimicrobial activity at 90 and 95°C reaching the greater logarithmic reductions when combined with acid pH. The results show the capacity and usefulness of a by-product of the agri-food industry, such as grape extract, to improve the food safety of rice products, especially when combined with mild thermal treatments.

Keywords: *Bacillus cereus*, Grape extract, Antimicrobial effect, Rice, Food safety

Poster

Influence of cold plasma treatment on corn starch

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Plasma technology is considered one of the new green technologies available for food and materials processing. Starch, a polysaccharide of plant origin, with a structure composed of amylose and amylopectin molecules has great nutritional and industrial importance. The objective of this work was to improve corn starch's chemical and structural properties by applying dielectric barrier discharge (DBD) plasma treatment.
The effects of DBD plasma treatment on corn starch composition, crystallinity, solubility, turbidity, water absorption, and morphology were evaluated by varying the plasma excitation frequency (100 to 300 Hz) and processing time (10 to 20 min) at a constant electrical potential difference (20 kV). Analysis of amylose content, solubility, water absorption index (WAI), turbidity, FTIR, contact angle, and Scanning Electron Microscopy (SEM) were performed to characterize the material before and after treatment.
The highest change in most starch properties occurred when applying an excitation frequency of 200 Hz after 20 min of treatment at 20 kV. Amylopectin content increased by 8% (from 76 to 82% w/w) due to internal branching reactions that occurred on amylose. The chemical changes induced a lower starch solubility and higher hydrophobicity which improved the film formation ability of this starch.
Water absorption index and turbidity remained stable after plasma treatment. The FTIR 1045/1022 cm^{-1} and 1022/995 cm^{-1} bands ratio indicated a change in the ordered structure in the external region of the starch and higher crystallinity. The morphology of the starch granules showed that plasma treatment created some cracks and pores in the granules but did not affect their integrity.
These changes facilitate the gelatinization of corn starch which is interesting for several applications. The lower amylose content may improve digestibility which can be interesting for some food products.

Emerging processes & hurdles technologies

Poster

A newly designed ohmic heating cell for establishing microorganism destruction kinetics

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Ohmic heating is a rapid and volumetric internal heating process based on the generation of heat within a food matrix due to its resistance to the passage of an electrical current. A long-standing interesting research was carried out on the evaluation of the efficiency of this process to inactivate microorganisms. Early literature has been inconclusive on the nonthermal effects of this process compared with conventional thermal heating. This discrepancy is the result of using different complicated ohmic heating systems and the unkown behaviour of microorganism's under the combined effect of heating and electrical field. Therefore, this study was aimed to design a new laboratory scale ohmic heating system able to assess easily the death kinetic of microorganisms as the capillary tubes used for conventional thermal process. A new small cell of 3 ml active volume was designed and validated in our laboratory. The gap between the two electrodes is only 3 cm which leads to fast heat of food liquids in a continuous applied voltage gradient ranging from 20 to 90 (V/cm) while maintaining the target temperature during holding time. Trials with salt and sugar solutions were performed to define the coldest spot of the cell as one of the main critical processing factor. Model solutions were heated under agitation at various temperatures up to 120 ºC and at different voltage gradients. Uniformity of temperature in the cell was confirmed by comparative temperature measurements at different locations inside the cell. Come-up times (CUT) for the 3 ml of liquid varied from 10 to 50 seconds which is comparable to those obtained using capillary tubes in conventional thermal bath. CUT depends on the electrical conductivity of food, target temperature, voltage gradient and proportional–integral–derivative (PID) temperature control loop. Death kinetics of selected microorganisms was tried under defined ohmic heating conditions while monitoring coldest point time-temperature profile. Obtained kinetic parameters (D and Z values) were compared with conventional thermal bath. This new developed ohmic cell is an appropriate and practical tool for establishing the microbial destruction rate under ohmic heating comparing to conventional thermal process.
Keywords: Ohmic heating, microbial death, kinetic destruction, electroporation

Emerging processes & hurdles technologies

Poster

Protein aggregates to replace texturing agents in clean label dairy products

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The PROFILAP project [April 2021 - March 2022] aimed to produce and use protein aggregates studied in PROFIL in order to replace the usual texturing agents such as carrageenans and modified starches in two selected “clean label” dairy products, the cream desserts and the cream cheeses.
In detail, we first inventoried various protein aggregates amongst fractal or microgel ones, and then selected and characterised the most functional one, i.e. large fractal aggregates, regarding the 2 selected dairy products. Then, we optimised their manufacture by studying the effect of 1. [whey protein isolate (WPI)], 2. [NaCl], 3. [OH-] ramp, 4. thermal scale, 5. flow regime and 6. type of chambering i.e. static or dynamic.
Then, all the levers influencing the development of the best technological itinerary to manufacture the 2 selected dairy products were studied: contents of protein aggregates and fat, homogenization parameters such as the number of passes, the pressures on the first and second head and the temperatures throughout the process were studied in order to build the most robust and sober technological itinerary from the bench scale to the pilot scale. Finally, two continuous technological routes were developed up to a scale of 500 l.h-1.
Once optimised, the two target products were organoleptically tested at ONIRIS by a panel of 54 tasters. For the most successful product, the cream dessert, an overall score of 15.50/20 combining textural and sensory characteristics was awarded, proving the potential of the technology. Similarly, the viscosity and the firmness of the current creams and of creams from the market were similar.
The proof of concept is thus made that texturizers can be replaced in some dairy products by protein aggregates to obtain "clean label" products or to design new products such as cereal- or legume-based desserts or other mixed products.

Poster

Electrically-driven separation of proteins and flavour molecules

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Separation processes are essential for the production of purified ingredients and the recovery of valuable components from waste streams. Classic thermal- and chemical-based separation techniques often require harsh conditions and extensive amounts of energy, especially when (dilute) liquid streams are processed. To reduce the environmental impact, novel sustainable separation techniques should be developed, such as electrically-driven separation.

Electrically-driven separation relies on switching of the interaction between a target molecule and a material surface (the electrode) when the direction or the strength of an applied electric field is changed. We apply the principle of capacitive deionization to separate larger biomolecules, such as proteins and flavours, and improve the separation capacity and selectivity by designing electrically-responsive polymer coatings. These coatings alter their characteristics in response to an external electric field, for example by (de)protonation, collapsing, swelling, internal restructuring, or changing their exposed groups on the surface. Consequently, the chemical functionality, charge and/or wettability of the material are affected, and interaction forces with target molecules are impacted. By removing the electric field stimuli or changing their direction, the original properties of the material are regained. This “switching behaviour” allows precise control over the interaction between the polymer coatings and target molecules and therewith enables selective adsorption and desorption.

This research focuses on the development of electrically responsive polymer coatings and studies their switching behaviour. The chemical and structural functionality of these novel materials and their capacity and selectivity in adsorption and desorption of proteins will be reported. The preliminary results show a positive proof of concept.

Poster

Effect of inactivation on Escherichia coli on the treatment chamber materials and packaging materials in intense pulsed light treatments

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In this study, the inactivation effect of intense pulsed light as the treatment chamber materials and packaging materials was investigated. The UV-C light amount of the light source of the control was 3.595W/m^2. The UV-C light quantity of quartz with a thickness of 1mm was 3.356W/m^2, acrylic 0.878W/m^2, and glass 0.06W/m^2, and the light transmittance was 93.4% for quartz, 24.4% for acrylic, and 1.7% for glass. As for the bactericidal effect on the materials of treatment chamber, quartz showed the same inactivation effect as the control regardless of thickness of material. A 1 mm thick acrylic showed a killing effect of 1.1log after 60s, and 5.0log after treatment for 180s. Glass had no sterilization effect regardless of its thickness. All of the death curve pattern except for glass showed a bi-phasic form. For the death rate constant and D-value, the k_1 was 0.287s^{-1}, k_2 was 0.072s$_{-1}$, the D_1-value was 8.02s and the D_2-value was 31.87s. and the death rate constant and D-value. D values were D1=8.11s, D2=33.87s for quartz, D1=127.94s, D2=54.83s for acrylic, and D=575.75s for glass. According to the measurement of the light penetration rate of each container packaging material in pulsed light treatment, there were differences in the UV-C penetration rate depending on the materials as the rate of PP, OPP, PE and PET was 91.3%, 89.7%, 89.5% and 1.8%, respectively, against the control groups. In terms of the containers made of 20? thick PP, around 6log of bacteria were killed after 20s treatment, and all bacteria were killed after 60s treatment. In terms of the containers made of 30? thick OPP and PE, 6log of bacteria were killed after 30s treatment, and all bacteria were killed after 60s treatment. PET had lower sterilization effects than other packaging materials. As the packaging materials thickened, the light penetration rate tended to be decreased, but did not have significant differences, except for PET. The study found that quartz has the highest sterilization effect among the materials of treatment containers in pulsed light treatment, and PP is the best material for food packaging containers.

Emerging processes & hurdles technologies

Poster

Low energy electron beam (LEEB) as alternative nonthermal decontamination technology for dry food surfaces

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Dry food products are often highly contaminated, and resistant microorganisms, such as bacterial spores, can be still viable and multiply if the product is incorporated into high moisture food products or rehydrated. Traditional technologies for the decontamination of these products have certain limitations and drawbacks, such as alterations of product quality, environmental impacts, or carcinogenic potential. Nonthermal low energy electron beam (LEEB) is a promising technology for microbial inactivation on dry food surfaces, which has shown potential to solve these limitations. Due to the limited penetration depth of LEEB (≤ 300 keV), product-process interactions can be minimized by maintaining product quality. Relevant spore inactivation efficiency supports the application of LEEB. Spores from Geobacillus and Bacillus species were treated with a labscale LEEB at energy levels of 80 and 200 keV. The spore resistances were expressed as D-values (the radiation dose required for one log10 reduction at a given energy level). The results revealed that the spore inactivation efficiency by LEEB is comparable to that of other radiations and that the inactivation curves are mostly log10-linear at the investigated dose range (3.8 – 8.2 kGy at 80 keV; 6.0 – 9.8 kGy at 200 keV). The D-values obtained from the wildtype strains varied from 2.2 – 3.0 kGy at 80 keV, and from 2.2 – 3.1 kGy at 200 keV. Bacillus subtilis mutant spores lacking a/b-type small, acid-soluble spore proteins showed decreased D-values (1.3 kGy at 80 and 200 keV), indicating that spore DNA is one of the targets for LEEB inactivation. The results revealed that bacterial species, sporulation conditions and the treatment dose influence the LEEB inactivation. This finding indicates that for the application of this emerging technology, special attention should be paid to the choice of indicator, physiological state of the indicator and the processing settings. A first demonstrator for LEEB with a capacity of one ton per hour has already been introduced into the food industry for the decontamination of herbs and spices. Proposed inactivation mechanisms, product-process interactions, limitations and upscaling potential, as well as future trends and research needs of this emerging technology will be critically summarized

Emerging processes & hurdles technologies

Poster

Investigation of high throughput microfluidics on several microalgae cultures – Evaluation of proteins recovery and comparison with ultrasonic treatment.

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Due to biological and metabolic richness of microalgae, their production is booming. A strong potential for large-scale application is expected in the industry. Numerous works are therefore dedicated to the improvement of processes that lead to the extraction of molecules of interest. A classical process generally encounters different steps, such as cells harvesting and concentration, extraction of molecules of interest and their purification. Several challenges have to be overcome due to the resistance of the cells to breakage and, on the other hand, due to the complex composition of the obtained cell mixture. Energy consuming mechanical devices, such as high-pressure homogenizers or bead milling, and/or unfriendly chemical substances are generally used for the cell rupture step. Energy and environmental constraints also explain the necessity of designing new devices and methodologies. This study investigates the effect of microsystems at high throughput on cells suspensions, as an intensified and intermediate way of altering cells structure. Microsystems at high throughput allow developing turbulent flows with high shear stress and elongation effects; they have already proven to be efficient in producing up to about 50 L/h of liquid/liquid or gas/liquid dispersions. In the present work, cultures of different species of microalgae have been submitted to one to several passes through a cross-slot microsystem. Its effect has been characterized determining the level of released proteins. Ultrasonic treatments of the cultures have been made in parallel for comparison. Complementary tests were also made adding isopropanol in order to couple a solvent extraction to the mechanical treatment. The results confirm a variability of cell wall resistance depending on the treated specie and on the physiological condition of the cells (nitrogen stress). Positive effects of the microsystems were observed with *Parachlorella kessleri* submitted to nitrogen stress. The recovery rate of proteins was shown to be enhanced with nitrogen stress, reaching 22%; comparatively, ultrasonic treatment allowed recovering 28% of proteins. In these conditions, the specific energy consumption per cell dry mass was eighteen times higher using ultrasonic system. The use of isopropanol, added after several passes of cells through the microsystem had a rather slight effect on protein recovery.

Poster

Gelling properties of black soldier fly (Hermetia illucens) larvae protein after ultrasound treatment

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H. illucens, black soldier fly larvae (BSFL) is one of the sustainable sources of protein however, the research on the functionality of BSFL proteins is limited and need to be explored to increase consumer acceptance. The aim of this study is to create a gel system from BSFL protein and evaluate the impact of ultrasound treatment at different exposure time (5, 15, 30 min) on the size, structure, and gelling properties of BSFL protein. The highest gel strength was found after 15 min of ultrasound treatment. The rise of the particle size and surface hydrophobicity was observed till 15 min of treatment. The water holding capacity of the gels were significantly higher after ultrasound treatment. High elastic modulus was observed after 15 min of ultrasound treatment. Lastly, the gel’s pore size was investigated by confocal laser scanning microscopy (CLSM) coupled with image analysis.

Emerging processes & hurdles technologies

Poster

Biobased formulation films as possible replacement for synthetic (polymeric) food packaging material

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Substantial number of conventional food packaging consists of non-degradable and petrochemical based materials causing environmental issues. Petroleum based polymers are mostly common used materials for multilayer material production, since they fulfil requirements with respect to its barrier and mechanical properties related to its application on sensitive food products. However, these multilayer materials are often not degradable or hardly recyclable. Thus, scientists are making important efforts in overcoming mentioned issues by production of novel biobased and biodegradable materials. Unfortunately, they often lack barrier to gases and water vapour and can hardly be used as single layer materials for commercial purposes. Therefore, new era relies on enhancing barrier properties of biodegradable polymers in various manners with coatings being one of the solutions. The aim of this study was to coat poly(lactic acid), PLA film with biobased coating (gelatine, chitosan) in order to replace environmentally synthetic bilayer foil (such as oriented poly(ethylene-terephthalate)/polypropylene, OPET/PP). Coating was made from biopolymers and additionally enriched with natural compounds that act as crosslinkers of biopolymer matrix. Changes in gas and water vapour barrier, colour and transmittance were studied. Comparison to OPET/PP film, used as benchmark (control) was provided in order to check the possibility of using prepared formulation of biopolymer coated PLA, with biobased properties, as cover foil for storing different food products (such as fruit jams in plastic PP buckets).
This work was supported by the project “Increasing the development of new products and services arising from research and development activities - phase II": Development of innovative products to increase food quality "-KK.01.2.1.02.0282.

Emerging processes & hurdles technologies

Poster

Effect of low frequency ultrasonic cavitation, ultraviolet and their combination on the disinfection of aquaculture pathogen Aeromonas veronii

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Aeromonas veronii has been identified as a relevant pathogen in aquaculture causing high mortalities in a different range of species and farming environments. Being able to control outbreaks of pathogen in recirculation aquaculture systems (RAS) is highly important to maintain a productive system. Over the last 10 years a small range of studies have focused on the application of cavitation as a disinfection method in aquaculture. In this study a low frequency (24kHz) ultrasound (US) system was tested against *Aeromonas veronii* to understand the requirements and effects of ultrasonic cavitation on disinfection and water quality. Additionally, a comparison with ultraviolet (30mJ/cm2 at 75% UVT, 7.5 L/m) disinfection and its combined effect with US was tested. For all trials *Aeromonas veronii* was inoculated in clear autoclaved distilled water mixed with a combination of phosphate-buffered saline (PBS) and tryptic soy broth (TSB). US reveled to be 607 times more energy demanding when compared to ultraviolet (UV) to achieve 3 log reduction of the target microorganism. There were no significant differences in disinfection potential when combining the two methods of disinfection. UV did not have any effect on water characteristics, while US showed an influence on several parameters. i.e., pH, conductivity (µS/cm) and production of H?O? equiv. (mg/L). pH dropped from 6.55 ± 0.23 to 6.35 ± 0.07, conductivity increased steadily over the trial reaching 100 µS/cm and H?O? equiv. reached concentrations of 2.76 ± 0.53 mg/L at the end of the trial. This study confirms the previously acquired knowledge on the high energy requirements of US for bacterial disinfection. UV systems showed to be more efficient, and its disinfection ability was not improved by pretreatment with US during the experimental trial. This study provides a better comprehension on the effect of ultrasonic cavitation on the water characteristics, allowing for better management of US technologies when used for disinfection in aquaculture systems.

Poster

Electric fields to support microalgae growth with a differentiated biochemical composition

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The search for raw materials with interesting nutritional content not competing for the arable land is a vital challenge for more sustainable and resilient food and feed production. Microalgae biomass is a potential source of functional macronutrients that can be produced under controlled environmental factors such as as light, temperature, nutrient availability, salinity and other physical stresses to leverage growth performance. Moderate electric fields (MEF) technology provides a new paradigm for the cultivation, harvesting and downstream processing of microalgae biomass. Depending on how the electric field is designed, a myriad of physical-chemical events can be controlled *in-situ* to change the biological activity of microorganisms and enzymes. In the present work, the influence of MEF application on the growth of microalgae *Pavlova gyrans*, known in the feedstock market due to its valuable biochemical composition and nutritional value, was assessed. MEF treatment was applied under optimal growth temperature conditions (between 24 and 28 ºC) at different at different growth stages and during the dark phase of its photoperiod. Results have shown that MEF when properly controlled do not change P. gyrans growth rate and influences its biochemical composition. At the end of the growth period increases up to 86 % and 66 % were observed for chlorophyll *a* and carotenoid content, respectively, as a result of the stress caused by electric field application. Increases in lipid, carbohydrate and protein fractions were also observed. This work demonstrated the potential of MEF application to microalgae as an innovative strategy to promote differentiated metabolic pathways during growth and thus influence biochemical composition of the produced biomass.

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Emerging processes & hurdles technologies

Poster

Scale up of layer-by-layer microencapsulation of probiotic lactic acid bacteria

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The layer-by-layer (LbL) microencapsulation of bacteria is an emerging process that will make it possible to develop more eco-friendly processes for lactic acid bacteria. This method takes advantage of the sequential deposition of oppositely charged polymers driven by electrostatic interactions to form nanoscale thin films on planar or colloidal surfaces. However, LbL is typically time-consuming, and automation of the polymer deposition steps is difficult to scale up. In this regard, this study aims to optimize the scale-up of LbL microencapsulation of *Lactiplantibacillus plantarum* WCFS1. Chitosan and alginate were used as cationic and anionic polyelectrolytes, respectively. Processing and formulation parameters like biomass production, washing steps, number of polymer layers and biomass/polymer ratio during the encapsulation were evaluated. The coating process was monitored by ζ-potential measurements. Numeration of culturable cells was performed before and after coating, after spray-drying with fructo-oligosaccharides and maltodextrin as the protective matrix and after exposure to simulated gastrointestinal conditions. Bacteria cultured at constant pH (pH 5.8) and harvested at the early stationary phase showed a lower decrease of cultivability after encapsulation (0.5 to 1 Log CFU/mL) than those produced under non-controlled conditions (without pH control, 4 Log CFU/mL decrease). The coating capacity of the alginate layer (second layer) was not affected by the reduction or elimination of washing steps between layers deposition. The addition of up to two coating layers (first chitosan and second alginate) did not significantly affect bacterial cultivability, which was negatively affected by the incorporation of additional layers. Furthermore, bacteria coated only with chitosan or by chitosan/alginate, exhibited constant ζ-potential up to 1:10 polymers:biomass ratio ($p>0.05$). The encapsulation capacity of chitosan and alginate was insufficient at a higher ratio (1:25) as suggested by noticeable changes of ζ-potentials. Spray-drying induced a decrease of cultivability of 0.8 and 0.4 Log CFU/mL in control uncoated bacteria and layer-by-layer coated bacteria, respectively. After rehydration, we obtained promising results regarding coated bacteria with chitosan and alginate subjected to simulated gastrointestinal conditions. The results obtained support the feasibility of scaling-up the LbL encapsulation process for the delivery of sensitive lactic acid bacteria strains while ensuring their safe arrival to the gut.

Emerging processes & hurdles technologies

Poster

Use of Plasma Activated Water for the functionalization of chick-pea flour

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The market of plant-based ingredients, in particular proteins sources, has increased constantly in the last years. There are various driving forces behind this dietary shift, including sustainability, health, and ethical considerations. Various products, as vegetable, cereals, pulses, fungi, have been exploited and are under current investigation for extracting proteins, but also starches and other ingredients. Beside the nutritional values, these ingredients possess also various techno-functional properties such as thickening and gelling ability, emulsifying, foaming, water holding and fat absorption, that are crucial for the formulation of foods, in particular for the formulation of meat and dairy analogues. In order to meet market demand, there is a need to have plant-based protein and ingredients that rival or have improved quality and functionality compared to the traditional animal protein ingredients they may replace.
Traditionally, ingredients are modified through chemical modification, however, to increase the sustainability of the ingredients, different alternatives have been investigated.
Plasma Activated Water (PAW), obtained by exposing water to cold plasma discharges, has emerged recently as a potential alternative for structural modification of ingredients aimed at their functionalization.
In the present research PAW, obtained through a corona discharge at 15kv, has been applied, for a 20 min exposure time to chickpeas flour to assess the modifications in the functionality. Specifically, technological properties such as emulsifying, gelling, water binding and foaming ability were measured in the flour after PAW treatment.
Results showed significant changes in the techno-functionality of the chickpea flour, due mainly to structural modification induced by the highly reactive species in PAW, confirming its potential as novel, green and uniform alternative treatment method to modify the properties of food ingredients.

Poster

Effects of sequential alkaline pH-shifting and ultrasound pretreatment on the structural and functional properties of soy protein isolate (SPI)?citrus pectin (CP) conjugates

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This study investigated the effects of sequential alkaline pH-shifting and ultrasonication on the structural and functional modifications of soy protein isolate (SPI) and SPI?citrus pectin (CP) conjugates. Results revealed that combined alkaline shifting/ultrasound pretreatment drastically increased the degree of graft of SPI?CP conjugates during the wet-heating process. Ultrasound pretreatment (22 kHz, 25 °C) at a power density of 13.5 W/mL and ultrasound duration of 6 min enhanced the degree of graft of SPI?CP conjugates, which was 79.57% higher than groups without any pretreatment and 15.87% higher than groups without ultrasound pretreatment. In addition to the grafting process, ultrasound was also observed to play a marked role in dissociating large SPI nano-aggregates into smaller ones and unfolding the SPI resulting in more favorable structures for the Maillard reaction and smaller particle size of Maillard products. Analysis of the protein secondary and tertiary structures suggested that the attachment of CP changed the spatial conformation of SPI and led to a looser protein structure. Furthermore, the combined application of alkaline shifting and ultrasound significantly elevated protein solubility adjacent to the protein isoelectric point and improved emulsifying properties of SPI with more fine microstructures of coarse emulsion droplets, indicating that sequential alkaline pH-shifting and ultrasound pretreatment can be a desirable method for protein-polysaccharide conjugation.

Poster

Effect of high isostatic pressure on the modification of the techno-functional properties of protein isolate from quinoa (Chenopodium Quinoa Willd) with pH variation

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Quinoa is being widely used as a source of alternative proteins, standing out worldwide as a superfood and, above all, for the quality of its proteins. Vegetable proteins, such as quinoa, have important physical and functional properties for the processing, storage and consumption of food, but their native form may have reduced functionality if compared to animal proteins and, therefore, their use may be more limited. Therefore, methods such as high isostatic pressure (HIP) and pH adjustment are being used to modify proteins technofunctionality. The potential of API combined with pH adjustment in modifying the structure and techno-functional properties of quinoa protein isolate (QPI) was evaluated. IPQ dispersions (5%; w/v) were processed at HIP (260 and 540 Mpa) with different pH values (3.5 and 10.50), for 10 min at 25°C and the control was performed using samples no processing. Pressurization combined with pH adjustment promoted a significant increase ($P<0.05$) in the water absorption capacity of QPI dispersions (3.00 g/g), with greater absorption at pH 3.50 (4.40 g /g). The oil absorption capacity (2.40 g/g) increased compared to the control, with maximum absorption at 260 MPa and pH 3.50 (3.53 g/g). There was a significant increase of 23% in the foaming capacity of the dispersions (32.50 g/g), with the maximum formation observed at 540 MPa and pH 10.50 (40.00 g/g). The foam stability of the QPI dispersions at 10, 30 and 60 min (28.75, 28.75 and 22.50 g/g), were significantly increased at 540 MPa and pH 10.50 to 37.50, 32, 50 and 32.50 respectively. Although the emulsifying capacity has been significantly reduced, it is still possible to indicate that QPI is a promising food ingredient for use in food formulation and pH adjustment combined with HIP processing are able to provide changes in proteins techno-functionality.

Emerging processes & hurdles technologies

Poster

Effect of Pulsed Electric Field Treatment on Plant Tissues with Heterogeneous Structure Assessed by Magnetic Resonance Imaging

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PEF treatment causes an increase in the permeability and conductivity of the cell membrane. This is explained by the creation of water pathways in the lipid domain of the cell membrane exposed to the external electric field. The change in permeability of the cell membrane is also associated with physical changes in cell structures, such as changes in intracellular and extracellular volume, as well as the volume of the vacuole, and consequently with the leakage of water and solutes from the intracellular to the extracellular space. Understanding such changes in target foods is of great importance for the desired treatment outcome. The aim of our study was to investigate the possible non-uniform effect of PEF treatment due to the structural heterogeneity of plant tissues. We selected three types of plant tissues that have different structural complexity and are commonly used in industrial PEF applications: apple, potato tuber and carrot taproot. Magnetic resonance imaging (MRI) was used to monitor the spatially-dependent effect of PEF treatment in the selected plant tissues. The transverse relaxation time T2 (also known as spin-spin relaxation time) was used as an indicator of the re-distribution of water and solutes in the tissues after PEF treatment. In addition, magnetic resonance electrical impedance tomography (MREIT), an MRI-based technique, was used to reconstruct the distribution of the electric field in the tissue during PEF treatment. Changes in T2 relaxation times were observed over the course of 6 hours after treatment to investigate the relationship between the local electric field and tissue structures. The results showed an increasingly inhomogeneous distribution of T2 relaxation times with increasing complexity of the plant structure (carrot > potato > apple). The ability to analyse water distribution and redistribution within the electroporated tissue is important not only for determining treatment intensity and the appropriateness of a particular treatment protocol in a given food matrix, but also for fundamental studies of material properties and their change as a result of processing with new technologies.

Emerging processes & hurdles technologies

Poster

Influence of ozone treatment on protein content of wheat (Triticum aestivum) during bulk storage.

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Title: Influence of ozone treatment on protein content of wheat (Triticum aestivum) during bulk storage.
The present study aimed to understand gaseous ozone exposure time and frequency of ozone cycle effect on protein content of wheat variety-GW 496 during storage. The bulk storage of wheat grain in metal silos has a major issue of insects and pests, which is controlled by gaseous ozone treatment. Because ozone leaves no residue and is environmentally friendly, ozone gas is the preferred and most practical method for treating grains while they are being stored in bulk. In this study, the ozone gas treatment was applied to wheat grain during bulk storage and its effect on wheat protein content was evaluated. A pilot-scale ozone disinfestation system for wheat grains was developed. 1000 ppm ozone gas concentration was fixed inside storage bin. The two-factorial experimental design on the influence of the parameters of ozone treatment on the protein content of stored wheat was carried out. Wheat grains were treated by gaseous ozone with various time durations (0 min, 30 min, 60 min, 90 min, and 120 min) and at various frequency cycles (7 days, 14 days, 21 days). The protein content of wheat during storage was significantly different after every 30 day interval up to 120 days of storage. A decrease from (10.40% to 9.13%) in protein content was observed for the control sample for the storage period up to 120 days, whereas 60 min of ozone exposure time and 14 days of ozone cycle increased the protein content from (10.40 to 10.58 %) in the ozone-treated sample for the storage period up to 120 days. On the other hand, excess ozone can also cause some negative effects on protein content. This study provided new insights into how stored wheat grain responds to ozone treatment and highlighted the role of treatment time durations and frequency of cycle for the protein content of stored wheat.
Keywords: Bulk storage, Ozone cycle, Ozone exposure time, Ozone, Protein content, Silo, Wheat.
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Poster

Textural modifications in Oaxaca cheese made with ultrasonicated raw milk

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In Mexico, Oaxaca cheese is the most popular cheese due to its melting properties. It is made by hand with raw milk in its region of origin (Oaxaca, Mexico). In this research, the effect of frequency (25 and 45 kHz) and time (15 and 30 min) of high intensity ultrasound (HIU) in fresh raw milk on the textural properties of Oaxaca cheese was evaluated. Results showed that 15 min of HIU shortened cheese melting time by up to 23.4 s compared to controls ($P < 0.0001$). Cheeses produced with ultrasonicated milk and 45 kHz presented higher melt areas ($P < 0.0001$). The lower pH (5.4) in cheeses produced with HIU compared to controls (5.7) positively modified functional properties during melting and solidification. Regarding thread formation, the results showed that with 25 kHz there was greater thread formation, regardless of the HIU time. The 45 kHz treatments (15 or 30 HIU min) and the controls formed fewer strings during the stringing test. In terms of hardness, cheeses made with milk sonicated at 45 kHz were softer, regardless of HIU time. Contrarily, the highest values ??of hardness were obtained with 25 kHz and in the controls. Lower pH values??produce calcium solubilization and reduced protein-protein interactions, resulting in a softer cheese. As with hardness, 25 kHz treatment produced higher values ??of chewiness (hardness*cohesion*elasticity) and gumminess (hardness*cohesiveness). HIU is a promising technology to positively modify the textural properties of Oaxaca cheese made with raw milk, producing softer cheeses with greater melting and strand-forming capacity.

Poster

Ultrasound impact on sensory acceptance of aged beef

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The study aimed to evaluate the impact of high intensity ultrasound (HIU) technology on the consumer acceptability of aged (5 and 10 days) vacuum-packed and dry-aged beef. Steaks (2.5 cm thick) were randomly assigned to the following treatments: CON = control meat without HIU nor ageing; WA5 = meat wet-aged for 5 d; WA10 = meat wet-aged for 10 d; DA5 = meat dry-aged for 5 d; DA10 = meat dry-aged for 10 d; HIU5 = HIU and wet-aged for 5 d; and HIU10=HIU and wet-aged for 10 d. After treatment, meat was placed in a shelf-life simulation for 5 d. General consumer and attribute liking test were conducted using 100 consumer panelists. Consumer acceptability and liking were analyzed using the 9-point test. A correspondence test was performed to determine the degree of association between the level of liking for the attributes (taste, smell, softness and juiciness) and the treatment effect. No significant effect ($P>0.05$) was observed in the consumer acceptability among treatments. Overall, application of HIU of meat before aging did not affect general acceptability nor the attribute liking of HIU5 and HIU10. Also, no difference was observed between the acceptability of wet- and dry-aged meat. The mapping of preferences indicated that the treatments were perceived as different. The sample with the highest acceptance by consumers was the DA5, and the sample with the lowest level of liking was the WA5. This evidenced a relationship between the treatment and the level of liking of consumers ($P<0.05$). As a conclusion, HIU applied to vacuum packed meat has potential as a safe method for aging bovine meat. These findings should be complemented by trained panel analysis, to explore in a more detail the sensory profile of meat subjected to HIU and aging.

Emerging processes & hurdles technologies

Poster

Process Intensification and Integration for Efficient Downstream Processing of Bioactives from Micro and Macroalgae

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Production aspects (fermentation and cultivation) were well studied and reported in the international literature. However, Downstream Processing (DSP) received scanned attention with an assumption that whatever is produced can be isolated and purified. In fact, many of the lab scale processes do not see the light of the day due to high cost of DSP. Algae (micro and macroalgae) are rich natural sources of many important bioactive compounds (proteins, pigments, lipids, carbohydrates, and polyphenols). They are becoming popular post-pandemic owing to their numerous applications in diagnostics, therapeutics, nutraceuticals, and functional foods. Our group has been active in the research area of DSP. Process intensification and integration enable increased productivity and in turn, increase economic viability. The efforts in this direction are presented in the current study. Most of the work is reported on wet algal biomass which is highly perishable, and very few reports are available on dry microalgal biomass. While, practically none found on dry macroalgae. Biomass cultivation requires a lot of space which is a major obstacle for industries especially those located in urban and metropolitan places. On the other hand macroalgae is cultivated in sea water along the coastline making it imperative to have the processing units in its vicinity. Drying of micro and macroalgae alleviates these constraints. In this context, biomass drying increases the shelf life and it also helps in eliminating the significant space requirement for cultivation, benefiting small-scale industries. Therefore, our study focuses on the process intensification and integration for efficient downstream processing of biomolecules from dry micro and macroalgae. All these aspects are discussed in this presentation.

Poster

Double layer coating in combination with modified atmosphere packaging preserve postharvest quality of fresh-cut melon during storage

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The objective of this study was to evaluate the effectiveness of antimicrobials such as herbal essential oils and coating materials to improve microbial stability of fresh cut melon. The melons "tashkandi" were harvested at commercial maturity in Mashhad, Iran. After washing and decontaminating with 200 ppm solution of calcium hypochlorite, the Peel and core were removed and flesh were cut to pieces of 4 cm long and 9 grams weight. Fresh cuts were immersed respectively in 1% alginate solution(2 min), 1% calcium chloride(2 min) and different solutions of chitosan(0, 1% and 2%)(2 min) and air dried at room temperature for 8 min. Thyme essential oil(0, 0.25% and 0.5%) were incorporated in chitosan solutions. Coated fresh cuts and control were packed in modified atmosphere (10% co2) and PETE clamshell containers and preserved in 4ºc for 8 days. Physicochemical characterization of the cut melons (total soluble solids, titratable acidity, color, texture and weight loss) were measured in 4 day intervals. Microbial and sensory tests were done at the end of preservation duration. Results showed that fresh cut melons treated by 1% chitosan had higher acidity and firmness. Color parameters redness(a*) and brightness(L*) were higher in this treatment. Furthermore fresh cut melons treated by 1% chitosan had higher acceptability and lower total counts and mold and yeast compared with other treatments. Results revealed that fresh cut melons treated with 0.5% thyme essential oil had lowest weight loss, lowest total count and lowest O2 in package. Furthermore results showed that fresh cuts packed in modified atmosphere had lower weight loss and more acidity compared with normal package. Modified atmosphere packaging of fresh cuts leads to lower redness(a*) and higher brightness(L*) and lower total count and mold and yeast. Totally it was concluded that coating material consist of chitosan(1%) and thyme essential oil (0.5%) and modified atmosphere packaging(10% CO2) can be evaluated as a safe and effective treatment that decreased microbial growth and maintain most qualitative parameters, color indices and sensory characteristics in fresh cut melons.

Keywords: fresh cut melon, chitosan, sodium alginate, thyme essential oil, modified atmosphere

Emerging processes & hurdles technologies

Poster

Uvaia (Eugenia pyriformis) fruit: a new source of phenolics compounds obtained by Pressurized Liquid Extraction (PLE)

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Uvaia (Eugenia pyriformis) is a Brazilian native fruit with great economic potential due to its excellent nutritional composition rich in phenolic compounds. Conventional extractions involve severe time-temperatures conditions and processing time resulting in partial bioactive compound degradation. In addition, the high amounts of solvents used makes this extraction not ecofriendly. Thus, alternative extraction methods, including pressurized liquid extraction (PLE), have been highlighted in obtaining bioactive compounds from plant matrices. This study aimed to obtain uvaia pulp extracts rich in phenolics and flavonoids compounds by PLE. The extraction was realized keeping the pressure constant at 10MPa. Extraction time was defined through extraction kinetics (100 ºC, 1.71 mL.min-1, 150 min). The best extraction condition was evaluated through a 2^2 rotational central composite design (DCCR). The effect of temperature (40 to 100 ºC) and percentage of co-solvent (ethanol) (60 to 99.5 %) on the content of phenolic compounds and flavonoids were evaluated. Extraction kinetics showed that extraction yield remained almost constant after 60 minutes. The total of phenolics and flavonoids ranged from 4.91 to 17.00 (mg GA .g-1 of dry uvaia pulp) and 2.19 to 7.91 (mg CAE.g-1 of dry uvaia pulp), respectively. The predicted extraction model showed that both temperature and solvent influence the phenolic extraction and the optimized condition was observed at 55 ºC and 70.0 % of ethanol. The presence of ethanol improves the extraction selectivity and the high temperature enable the breakdown of the linkages between bioactive and uvaia pulp matrix. Conversely, for flavonoids extraction high solvent concentrations and high temperature negatively affected the extraction. The antioxidant activity for extracts was 189,72 ± 10,34 µM Trolox.g-1 of dry uvaia pulp and 231,41 ± 10,96 µM Trolox.g-1 of dry uvaia pulp for phenolics and flavonoids, respectively. The results show that uvaia pulps is a rich bioactive source and PLE is an efficient method for its extraction

Poster

Black sage (Varronia curassavica Jacq.) extracts obtained with pressurized ethanol in an intermittent process

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Pressurized liquid extraction (PLE) is economically viable, sustainable, and ecologically free of residues of toxic solvents when ethanol is used. In this research, this technology was used to obtain optimized conditions to extract phytochemicals from black sage (Varronia curassavica Jacq.). Natural leaves of black sage were obtained from a biological field production. The leaves dried under low-temperature conditions were crushed and passed through sieves to standardize the particles (< 1,5 mm). Dionex ASE 150 Accelerated Solvent Extractor System (ASE) applied at Pressurized Liquid Extraction (PLE) was used in an intermittent extraction process. In the study of the influence of process on the extraction yield, a central composite rotational design (CCRD) was applied for temperature (T), static time (St) (contact time between the solvent and the matrix in each cycle), rinse volume (V), and number of cycles (C) as independent variables. In each experiment, approximately 5g of dried herb was used, and ethanol (99.5%) as solvent. In addition to the extraction yield as a dependent variable, the antioxidant activity was also evaluated by spectrophotometry, using the gallic acid curve pattern in the DPPH reaction (mg/g GAE) and for the inhibition of the ABTS+ radical, Trolox was used as a standard.
Of all the variables studied, temperature was the only one that influenced the extraction. The fact that the rinse volume (V) does not influence the yield, proves once again that this process, in addition to being fast, saves solvent. The best processing yield (11,46 g extract/100 g dry leaves) occurred at 70°C, 4 cycles with 8 min of static time, and rinse volume of 120 % the extractor cell (41 mL). For this extract, the antioxidant activity was 645.14 mg/g GAE and 1,331 µg Trolox/g dry leaves.
PLE in an intermittent process using ethanol as a solvent emerges as a fast technology that uses little solvent and is highly efficient in extraction. The use of ethanol characterizes it as a green technology that becomes ideal for the production of phytochemicals with antioxidant properties from black sage.

Emerging processes & hurdles technologies

Poster

Direct coupling of high intensity ultrasound to a crossflow microfiltration pilot for pulpy fruit juice clarification

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The objective of this study was to evaluate the direct coupling of high intensity ultrasound (HIUS) to a crossflow microfiltration pilot (tubular ceramic membrane of 0.2 µm average pore diameter, laboratory scale) in order to reduce the membrane fouling during the clarification of pulpy fruit juices. The HIUS probe was installed vertically 20 cm before the filtration membrane. The application of 1 min pulses at 30, 40 and 50% of amplitude and with different rest times (from 1 to 10 min) were evaluated. A transmembrane pressure of 76 kPa, a crossflow velocity of 5 m?s-1 and a temperature of 20ºC were controlled in the system. The permeate flux (Jp), the volume reduction ratio (VRR), the change in the physicochemical characteristics and the effect on the concentrations of bioactive compounds of jackfruit nectars with different pulp content were determined. The results showed that the fouling of the membrane decreased when the HIUS pulses were applied at shorter rest times. For the pulpiest nectar, Jp dropped by 52% after 40 min without HIUS, but a recovery of 80% was observed when HIUS was applied at 40% amplitude. For the less pulpy nectar, the HIUS efficiency was not highlighted because Jp decreased in all the conditions evaluated. Furthermore, an increase in the concentration of polyphenols in the permeate and of carotenoids in the retentate was shown. Until now, the coupling of HIUS to CMF improved the filtration performance when working with highly pulpy fruits such as jackfruit using as HIUS operating conditions, amplitude of 40-50% and a shorter rest time of pulse application. The coupling of these two technologies provided a solution to the problem of membrane fouling and could enhance the sensory and functional properties of the final products.

Emerging processes & hurdles technologies

Poster

Thermal and non-thermal decontamination of food formulations containing phycocyanin – influence of media pH and process intensity of quality characteristics and microbial inactivation

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Phycocyanin (PC) is a natural blue food colorant derived from microalgae, which has become an increasingly popular and sustainable alternative to chemical food additives. Due to its nature as a protein, various external influences lead to color losses, therefore limiting preservation of PC formulations by conventional treatments. Thus, the presented study is focusing on non-thermal decontamination of PC formulations at pH 3 and 7. Inactivation of *Listeria innocua* (Gram+) and *Escherichia coli* (Gram-) by Pulsed Electric Fields (PEF; 32 kV/cm, up to 200 kJ/kg) and high pressure processing (HPP; 600 MPa, up to 10 min) was investigated and compared to short-time thermal pasteurization (up to 70 °C, 2 s). Color retention as well as reversibility of protein aggregation were evaluated. Results showed sufficient inactivation levels for all treatments, which were facilitated at pH 3. In contrast to thermal effects, protein aggregation caused by low pH and short HPP exposure (≤ 2.5 min, 600 MPa) were shown to be reversible. For PEF treatment, the electric field itself did not seem to affect the proteins, however, especially at neutral pH the required high energy input levels and the associated temperature increase lead to irreversible protein aggregation. Altogether, process windows could be determined which allow for a sufficient microbial inactivation while simultaneously providing a best possible retention of PC color activity, therefore contributing to the industrial implementation of these technologies.

Poster

Impact of High Pressure Homogenization on the inactivation of spores in Sheep Milk

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Bacterial spores are a challenge to the food industries due to their resistance to chemical interventions of disinfection and physical treatments for inactivation. They can survive any treatment equivalent to pasteurization and germinate into vegetative cells under favourable conditions, thereby limiting the shelf life of milk. Processing techniques using thermal treatments such as Ultra High Temperature (UHT) (135 ?C for 4-8 seconds) have previously been used to inactivate spores in milk. However, the extreme heat applied during the UHT treatment can negatively impact the nutritional quality, taste, appearance, and sensory properties of the milk. Conventional homogenizers with pressures up to 50 MPa have been utilized in the dairy industry to reduce particle size and create stable emulsions prior to UHT treatment of milk. However, treatments up to 50
MPa are insufficient to cause bacterial spore inactivation. Previous literature shows that pressure and temperature have a synergetic impact on bacterial spore inactivation. Ultra-high pressure homogenization (UHPH) is an emerging technology that applies pressures in the range of 200 – 400 MPa and has the capability to inactivate spores due to the combined effect of high pressure and temperature at a very short treatment time (less than 0.5 sec).
Sheep milk is nutrient dense and contains almost double the fat and protein content of bovine milk. However, these properties make conventional thermal processing technologies (i.e. UHT) challenging for sheep milk due to protein denaturation and coagulation, protective effects of sheep milk fat etc. Sheep milk bio-actives have also been shown to be more sensitive to heat treatment. This study aims to investigate the impact of operating pressure and inlet temperature on *Bacillus* spores inoculated in sheep milk. The UHPH treatments are carried out using a pilot scale unit (FPG7575:S6300, Stansted Power Fluid Ltd., UK) with a maximum pressure of 400 MPa. The combined application of heat and pressure lowers the temperature needed for spore inactivation by a few degrees and decreases the treatment time.

Emerging processes & hurdles technologies

Poster

Impact of Ultra-High Pressure Homogenization on the inactivation of spores in Sheep Milk

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Poster

Characterising cleaning relevant properties of native model biofilms for efficient biofilm removal strategies

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Characterising cleaning relevant properties of native model biofilms for efficient biofilm removal strategies

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Objective

Because of their increased resistance against chemical, environmental and mechanical forces, biofilms represent a frequent source of contamination in the food industry. Thus, developing reliable cleaning strategies to control and remove biofilms is crucial. For that it is important to understand the relevant influences on the biofilm as well as their behaviour during growth and removal. This study aims to target this problem by characterising structural biofilm properties and to evaluate methods in regard to cleaning relevant properties in the frame of the Project Biomitate.

Methods

Microbacterium lacticum D84 (M. lacticum) was incubated in small petri dishes (Ø35mm) with milk broth for 12 days at 30 °C to grow a native biofilm model. After cultivation, the biofilm was analysed in regard to rheological and textural parameters.

Results

Rheological parameters, especially the young's modulus and the loss and storage modulus, provide essential information about the viscoelastic properties of the biofilm. A high young's modulus indicates a stiff substance, where more force is needed to disrupt a biofilm, which is correlating with cleaning relevant properties. With additional microscopic evaluation, qualitative data and the distribution of EPS components is visualised.

Conclusion

With the obtained parameters, information about cleaning relevant properties of M. lacticum biofilms is gained. Enhanced knowledge in this area can help improve cleaning procedures and optimize operational parameters. Further, the results of this study can be used to create a microorganism free biofilm imitate with correlating properties that can be applied for cleaning validation processes in the industry.

Acknowledgements
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Emerging processes & hurdles technologies

Poster

Semi-industrial scaling up of a membrane process to obtain a nutrient-dense citrus concentrate

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Citrus fruits and their juices are important sources of bioactive compounds such as provitamin A carotenoids (β-cryptoxanthin, β-carotene), and flavonoids (hesperidin, narirutin) that contribute along with vitamins, minerals and fibers to their beneficial health effects. Crossflow microfiltration (CMF) is a non-thermal and low energy consuming process increasingly used for insoluble solid concentration in liquid foods. As previously demonstrated at laboratory scale (membrane area 0.02 m²), an optimized CMF process allowed to obtain nutrient-dense foods, up to 8-10 times enriched in carotenoids and flavonoids, from citrus juices without increasing total soluble solids.

The aim of this study was to evaluate and validate at semi-industrial scale an integrated process including enzymatic liquefaction (pectinolytic enzymes), CMF with continuous retentate extraction (0.2 m², average pore diameter 0.2 µm, transmembrane pressure 2.25 bar, crossflow velocity 5 m?s^{-1}), and a final step of stabilization by pasteurization (84°C). The interest of the combination of these 3 successive unit operations was appreciated through the nutritional quality of the citrus concentrate, in particular carotenoid and flavonoid contents.

For carotenoids and hesperidin, concentration factors between 6 and 7 were reached. These values were slightly lower than the chosen volume reduction ratio (VRR = 8) due to 20% losses probably by oxidation. The retention of narirutin was found to be partial (below 50%). This result was linked to its lower hydrophobicity and so its lower association with the insoluble fraction retained by the membrane. Even with a 10-fold increase in membrane area (compared to the lab scale) and fully continuous operation, the permeate flux was still above 70 kg?h^{-1}?m^{-2}. It was repeatable for different production batches and stable up to VRR = 8 that was promising for higher VRR applications. Using a pasteurization value of 120 min (Tref = 70°C), the thermal stabilization step had no significant effect on the concentrate quality.

The whole process was therefore proved to be transposable and applicable at a semi-industrial scale, with good performance and robustness. It enabled the production of citrus concentrates with a much higher nutritional potential than the raw citrus juices and with a shelf life of several months at room temperature.

Poster

Developing artificial biofilm-imitates to establish a novel biofilm cleaning test system

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Developing artificial biofilm imitates to establish a novel biofilm cleaning test system

Introduction and objective

Biofilms are the most frequent cause of food contamination and thus a leading health and safety concern. To develop suitable sanitation methods against biofilms, a fundamental understanding of their growth behavior as well as their behavior during cleaning and removal is essential. However, studying biofilms remains challenging due to their heterogeneous and complex inherent properties. Hence, the aim of the present study was to develop and characterize simplified artificial biofilm imitates.

Methods

The imitates were based on single or mixed polysaccharide hydrogels (18 imitates) or on polysaccharide-protein hydrogels (34 imitates). They were analyzed based on rheological properties (G' and G'') and texture profile analysis, both associated with the behavior of biofilms during cleaning and removal, and compared to the characteristics of bacterial biofilms based on literature.

Results

For rheological properties, the overall lowest G' and G'' values of all imitates were measured for agar-carob (AC) imitates. AC imitates reported similar G' and G'' values (G': max. 500 Pa; G'': max. 100 Pa) to *Pseudomonas aeruginosa, Streptococcus mutants* and *Staphylococcus aureu*s biofilms. The texture profile of polysaccharide mixed hydrogels depended not only on the type but also on the concentration of the polysaccharide. When adding proteins, the imitates became firmer and more cohesive, but at the same time, adhesion was decreased. AC imitates showed high firmness and consistency, making good candidates for biofilm imitates, however, comparison to literature is challenging due to missing data.

Conclusion

The artificial biofilm imitates represent simplifications of native biofilms with similar mechanical properties and may prove helpful in developing a novel biofilm cleaning test system. Hence, current findings prove helpful for testing the efficiency of cleaning procedures or to develop mechanical removal strategies against native biofilms within the food industry. Further studies must include more complex imitate compositions to get closer to the native biofilm structure with greater mechanical heterogeneity and more complex geometries.

Acknowledgments

This study was carried out under CORNET (Collective Research Networking) within the project Biomitate (project number: FO999888198 and IGF-Project No.: 317 EBR).

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Emerging processes & hurdles technologies

Poster

Capitalizing the condensation of superheated steam for powder crystallization control

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A unique feature of superheated steam is that it condenses upon contact with food droplets or solids. The condensation, in addition to increasing the moisture content food material, rapidly increases the temperature of the food material to the saturation temperature of the steam. High temperature and moisture is excellent for inducing crystallization in certain food material. In this talk, we will examine how superheated steam can be used as a unique drying medium for controlling the in-situ crystallization of powder in spray dryers. We will also discuss on some of the learnings from the lab, when implementing superheated steam in spray dryers. Moving on from spray dryers, we will examine how superheated steam can be used to temper amorphous food powder as a means to control and induce crystallinity in the powder. We will discuss in detail on the strategy to control a superheated steam food powder tempering process.

Emerging processes & hurdles technologies

Poster

Choline chloride-based deep eutectic solvents: A computational and experimental study for extraction of flavonoids and phenolic compounds from soybean and okara

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This study aimed to use COSMO-SAC software to screen a set of solvents by evaluating the activity coefficient at infinite dilution of the isoflavones daidzein, genistein, glycitein, daidzin, genistin, and glycitin followed by experimental validation. COSMO-SAC screening was performed with 18 solvents, thirteen deep eutectic solvents (DES) containing choline chloride (ChCl) as HBA, and different carboxylic acids, sugars, and polyols as HBD. In addition to DES, water, 70% ethanol, 80% methanol, 70% ChCl, and 70% acetic acid were evaluated. With the best solvents, extraction experiments were performed for validation. Initially, soybean and okara were weighed and mixed with the solvents in test tubes of 10 mL (solid-solvent ratio 20 mg/mL). The tube was placed inside 50 mL containers containing water and jacketed for circulating water from a thermostatic bath to maintain the temperature. Extractions were performed by heating the mixture to 60 °C, under constant magnetic stirring at 600 rpm for 60 min. After the extractions, determinations of total flavonoids were carried out. After computer screening, it was found that the solvents with the highest interaction with the analytes were: 70% ethanol, 80% methanol, 70% acetic acid, 70% ChCl, and the DES ChCl: acetic acid, ChCl: lactic acid, ChCl: glycerol, ChCl: formic acid. The DES ChCl: glucose presented the worst performance in the computational modeling and was also used for validation. Experimentally, the solvents that most extracted isoflavones from soybean were ChCl:acetic acid>70% Ethanol>70% acetic acid>80% Methanol>70%ChCl>ChCl:lactic acid>ChCl:glycerol>ChCl:formic acid>ChCl: glucose. For okara, the best solvents were ChCl:acetic acid>Methanol 80%>ChCl 70%>ChCl:lactic acid>acetic acid 70%>Ethanol 70%>ChCl:formic acid>ChCl:glycerol>ChCl:glucose. Furthermore, it was observed that all total flavonoid results were higher for soybean, with the maximum concentration of 1.05 mg equivalent of catechin/g of the sample obtained with DES ChCl: acetic acid. Therefore, COSMO-SAC can be used as a tool to assist in the screening of solvents in extraction processes and DES can be used as an alternative for the extraction of isoflavones, replacing conventional solvents such as ethanol and methanol.

Poster

Can non thermal processing methods like pulsed electric field and cold plasma alter dairy protein functionality?

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Proteins in today's market are gaining more attraction from customers due to more significant shift on healthy and sustainable living. Dairy proteins serve as complete proteins however there is a problem of functionality especially with dairy proteins like milk protein concentrate 85 (85% protein) which hinders their use in the development of new products. In order to overcome this challenge with milk protein concentrates, the industry is looking into several alternative technologies. Among these alternative technologies, non thermal processing has been gaining a lot of attention in the food space owing to minimal processing labels which drives the consumer's interest. Non thermal technologies such as cold plasma and pulsed electric fields were currently studied to understand the effects of processing parameters on modification of dairy proteins for various applications. Plasma is the fourth state of matter and consists of electrons, proteins, atoms, and these particles together initiate a chemical reaction. The low temperature plasma is also called cold plasma or non-thermal plasma and it is known to modify the functionality using surface modification. PEF works on the application of short high voltage electric pulses through the food product for a few microseconds. Radio frequency cold plasma systems were employed at different combinations of time with constant Ar and CO 2 flow rates at 10 and 25 cm3/min and RF at 120 W to MPC85 spray dried powders. For the pulsed electric field treatment various combinations of temperature, electric field strength and frequency were tested for reconstituted liquid MPC85 followed by spray drying and various protein functionality analysis were carried out. The results from cold plasma treatment and pulsed electric field treatment showed improvement in functionality for product applications

Emerging processes & hurdles technologies

Poster

Effect of strengthening green coconut pulp with proteins on the survival of probiotic lactic bacteria and on the rheological properties of a fermented product

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The growing search for healthier lifestyles has led to a significant increase in the demand for coconut water. The green coconut pulp is edible, however, generally the consumption of the fruit in natura is limited to water, in such a way that the pulp and the husk are discarded. The objective of this work was to study the effect of strengthening green coconut pulp with non-dairy protein on the survival of lactic acid bacteria Streptococcus thermophilus and Lactobacillus delbruecki subsp. bulgaricus, the probiotic bacteria Lactobacillus acidophilus LA-5 and Bifidobacterium Bb-12 and the rheological properties of fermented green coconut pulp. For the development of this work, the preparation of green coconut pulp was carried out, followed by heat treatment, addition of 2% lactic ferment containing the bacteria Streptococcus thermophilus, Lactobacillus delbruecki subsp. bulgaricus, Lactobacillus acidophilus LA-5 and Bifidobacterium Bb-12, addition of different concentrations of pea protein (2 and 3 %), fermentation and storage at 7 ºC for 30 days. Determinations of pH, microbiology, texture, and rheology were carried out. The increase in the protein content in the fermented green coconut pulp promoted a greater amount and a greater survival of the colony-forming units of probiotic bacteria. Statistical analysis of the results obtained in the determination of variations in microbial populations of fermented products during storage at 7 ºC for 30 days showed that there was no significant difference ($p>0.05$) between microorganisms. Therefore, the addition of 2% or 3% of pea protein allowed the survival of the bacteria Streptococcus thermophilus, Lactobacillus delbruecki subsp. bulgaricus, Lactobacillus acidophilus LA-5 and Bifidobacterium Bb-12. The addition of different levels of pea protein resulted in a fermented product based on coconut pulp, with a pseudoplastic behavior. From the elaboration conditions employed, it is concluded that it is possible to produce a functional and quality fermented product, with green coconut pulp and non-dairy protein, without emulsifiers and milk.

Poster

Pectin-based active edible coatings applied in papaya: rheological and surface properties

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Edible coatings based on natural products have proven to be a sustainable and low-cost alternative for increasing the shelf life of fruits. From this perspective, the objectives of this work were the development and characterization of pectin-based edible coatings (4g/100g solution), incorporated with oil-in-water emulsion containing orange essential oil (0.6%) as an active ingredient, in addition to its application in papaya. For the formulation considered control there was no incorporation of the emulsion. The coating forming solutions were characterized in terms of their rheological properties at 40ºC (steady and oscillatory shear tests) and surface properties (contact angle, surface tension and wettability). The coating forming solutions were applied to the fruit surface by two different methods: immersion and aspersion. The rheological behavior of both control and emulsified active solution were similar, among the most known mathematical models to describe the rheological behavior of a fluid, the Newtonian achieved better fits, with quadratic ratios above 0.9967 for both formulations tested, despite a decrease of approximately 26% of viscosity with oil addition. In frequency sweep analysis, performed within linear viscoelasticity range, samples exhibited G’

Emerging processes & hurdles technologies

Poster

Differential Scanning Flourimetry of Glucose Oxidase at High Hydrostatic Pressure

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Most efforts associated with high pressure processing (HPP) of foods have focused on killing pathogens and spoilage microorganisms as well as on the inactivation of intrinsic, deleterious enzymes. However, it is well-known that high hydrostatic pressure (HHP) stabilizes and activates several enzymes. Processing enzymes play an important role in the production of flavors and other added-value food products. We and others have researched the potential application of HHP to enzyme-catalyzed processes. However, a fundamental understanding of the relationship between enzyme structure and the effect of pressure is still missing. Here we report the use of high-pressure differential scanning fluorimetry to characterize the stabilizing effect of high hydrostatic pressure on glucose oxidase (GOx). Glucose oxidase solutions were prepared in phosphate buffer pH 5.1. Approximately 0.5 mL of GOx were pipetted into a quartz cylindrical cuvette caped with Teflon plungers and inserted into a high-pressure reactor with sapphire windows. The high-pressure reactor was placed in a fluorescence spectrometer. The cell was then pressurized and then heated at 1 ?C/min from 20 ?C to 90 ?C. The sample was excited at 280 nm and fluorescence at 350 nm was continuously measured. The first derivative of the fluorescence was calculated. The melting temperature Tm increased from 69.7 ?C at 0.1 MPa to 80.6 ?C at 300 MPa. The results are consistent with measurements of residual activity experiments after thermal treatment at HHP. A decrease in intrinsic fluorescence upon pressurization suggests that HHP folds the protein burying deeper hydrophobic tryptophan residues. Then thermally induced denaturation is revealed by the increase in fluorescence with the increase in temperature.

Poster

Effect of combined disinfection with peracetic acid and power ultrasound on quality attributes of whole strawberries (cv. Ágata)

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Disinfection step is one of the most important operations in fresh-cut production where different strategies are used to minimize and reduce microbial hazards. Cavitation bubbles formed by power ultrasound (US) can be applied in decontamination step because of their ability to remove or reduce microbial loads. However, cavitation can affect product quality because of tissue rupture. The aim of this work was to apply a combined disinfection methodology involving power ultrasound and peracetic acid (US–HPA) for disinfection of strawberries (cv. Ágata) and evaluate its effect on product quality attributes. Two different acoustic power densities (APD) and frequencies were assayed. Classic disinfection with HPA alone was performed as control. Parameters associated with disinfection step (HPA concentration, pH, conductivity and microbial counts) were determined before and after disinfection treatment. Parameters associated with ultrasound performance in combined US-HPA treatment were measured: dissipated power and acoustic power density (20 and 42 W/L). Parameters associated with product quality before and after treatments were measured: microbial counts, pH, total soluble solids (TSS), instrumental color, instrumental texture, respiration rate, vitamin C content, total phenolic content (TPC) and antioxidant capacity (AOC). In addition, a phenolic profile was conducted by HPLC-DAD.
Significant differences ($p < 0.05$) were found between US-HPA and HPA disinfection treatments, but no significant effect of APD or frequency was determined. Additional average reductions of 0.8 log/g for total aerobic counts and 1.3 log/g for Enterobacteriaceae were obtained for combined US-HPA treatments. In the case of moulds and yeasts, differences between disinfection treatments were not significant, presenting reductions between 2.0 and 2.4 log cfu/g. As for quality parameters, no significant differences were found for TSS, pH, instrumental texture, instrumental color and respiration rate between treatments. TPC and vitamin C content in combined US-HPA treatments showed a slight increase with respect to HPA disinfection, but antioxidant capacity was similar in all samples. Catechin content was not affected by treatments, while a 10% reduction in ellagic acid content was obtained in all treatments. Identified anthocyanins, cyanidin and pelargonidin, were affected by disinfection treatments but with no identifiable trend.

Poster

Cellulose-based film for vegetable packaging application: case study on broccoli

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Modified atmosphere packaging (MAP) has proven to be a key technology for extending shelf-life of fresh fruits and vegetables. The main disadvantage of MAP is the extensive use of petrochemical-based films. Replacing these films with bio-based and biodegradable alternatives could reduce environmental impact of plastics. The aim of this work was to evaluate the suitability of a cellulose-based film for broccoli packaging and to study its effect on product quality.

Broccoli heads (cv. Legacy) were cut into florets, washed, disinfected (NaClO), dried and packaged in micro-perforated polypropylene (PP) and micro-perforated cellulose-based film (Cellulose). Broccoli packaged in macro-perforated polypropylene was used as control (C). Samples were stored at 4 °C throughout 21 d. Package internal O_2 and CO_2 concentrations, mass loss (ML), instrumental color and sensory attributes (color, odor and overall appearance) were evaluated during storage. Two-way ANOVA considering packaging condition, storage time and interactions was performed, and when significant differences were observed Tukey's test was applied ($p < 0.05$).

Cellulose samples reached significantly higher CO_2 (5.5%) and lower O_2 (13.9%) equilibrium concentrations compared to PP samples (2.9% and 18.0% respectively). Gaseous composition inside cellulose packages was closer to recommended values for broccoli storage. Broccoli in cellulose-based film showed the highest ML at the end of storage period (15.5%) compared to PP (1%) and C samples (8.9%). However, this higher ML did not have a significant impact on sensory quality, since no significative differences were found on sensory attributes between Cellulose and PP samples. Broccoli in MAP retained color of freshly harvested broccoli (L^*=43.1, hab=115.1) regardless of applied packaging film, while C samples showed a significative increase in L^* (to 57.9) and decrease in hab (to 87.2). Therefore, micro-perforated cellulose-based film could be a viable packaging alternative for broccoli, positively impacting the reduction of plastic waste. Additional studies should be considered to determine the suitability of this film for packaging broccoli at other storage temperatures.

Poster

Effect of Sonication Pre-treatment and Drying Temperature on Avocado Seeds (Persea Americana) Drying Kinetics and Flour Quality

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Avocado finds its primary use as a fresh product, but there is a growing interest in its industrial use. Processing of the fruit originates many by-products and wastes, represented by seeds and peels, whose amount can reach 21-30% of the initial weight of the fruit. This study investigated the effects of sonication (35 kHz 30°C) pre-treatment and drying temperature (40-50-60°C) on Avocado Seeds (Persea Americana) drying kinetics and flour quality. For modelling the drying kinetics, five different empirical equations were tested, and the Modified Page model (II) indicated a better fitting to the experimental data. The sonication pre-treatment reduced the drying time. The seeds flour total phenols, and tannins contents showed that only for 60 ºC the sonication of the product before drying resulted in better preservation. However, sonication pre-treatment reported a higher color deterioration, particularly in the samples treated at 50 and 60°C.

Poster

Production and viability time of a probiotic powder from milk cultured with S. Thermophilus and enriched with encapsulated L. Fermentum before drying.

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Fermented milk is the leading carrier of probiotics, but their cell viability decreases during storage, even under refrigeration. The literature has reported the production of fermented milk powder with encapsulated microorganisms. This study investigated the impact of encapsulation and drying on *L. fermentum* cells viability during storage at RH of 11, 44, and 64%. For that, *Lactobacillus fermentum*, free (LFL) or encapsulated (LFE), was added to milk fermented by *Streptococcus thermophilus* before dehydration by freeze-drying (LIO), Cast-Tape Drying (CTD), and Vacuum Cast-Tape Drying (V-CTD). CTD has been used to dehydrate heat-sensitive products by spreading and drying a thin suspension layer on a flexible-and-impervious mat heated from its bottom by a controlled-temperature fluid. The semi-log model described the thermal inactivation kinetics of *L. fermentum* correctly during drying. This approach allowed the calculation of parameters analogous to the decimal reduction time D and z. There was a reduction of less than 1 log CFU/g in fermented milk dried at 50 ºC and 60 ºC, and approximately 2 and 3 logs reduction when dried at 70 ºC and 80 ºC, respectively. The fermented milk dried between 50 ºC and 80 ºC remained with viability above the expected for probiotic products (minimum of 106 CFU/g). z values were 20.3 °C for LFL, and 22.3 °C for LFE. After 180 days of storage, the powder samples dehydrated by CTD at 50 °C had only 1 log reduction for LFL and LFE at 11% and 44% RH. LIO samples with LFL, stored at UR 44%, showed a 2.5 log reduction. No viable cells were present in powders stored at RH of 64% after 10 days. Therefore, CTD at 50 °C or 70 °C produces fermented milk powders with encapsulated *L. fermentum* that maintain cells' viability for at least 180 days at room temperature.

Emerging processes & hurdles technologies

Poster

Marination performance and quality of chicken thigh meats: comparison of radio frequency and conventional thawing processes

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Thawing process has an important effect on freeze-thawed meat quality. The studies recently conducted in lab-scale conditions showed that radio frequency (RF) thawing revealed successful results by saving energy and decreasing mass losses. In poultry industry, freeze-thawed meats are used for marinated and emulsified products. From this viewpoint, the objective of the study was to determine the marination performance and quality of chicken thigh meats thawed with RF heating and compare the results obtained from conventional thawing processes.

Commercially frozen chicken thigh meat bulk (≈9 kg in a retail box of 60x40x10 cm) was thawed in an RF system (a free oscillating pilot scale staggered through field electrode system, 10 kW, 27.12 MHz) at 17.5 cm electrode gap and 2000 V potential. For conventional approach, the bulk meat was thawed in a temperature-controlled incubator with circulated air at 22 °C (CA22) and 4 °C (CA4). Thawing process was completed when the internal temperature reached to ≈ -1°C. Thawed samples were marinated within a phosphate-salt solution by using a hand-held single needle injector under 2 psi brine pressure with a targeted final 10% weight gain and 2% salt concentration. Unfrozen meat samples were also marinated as a positive control. Quality analysis was conducted, and the results were compared for significant difference.

Freeze-thaw process decreased the marination yield and increased the cooking loss regardless the thawing process used. Cooking yield in CA4 (13.30%) was significantly lower than RF (16.10%) and CA22 (17.90%) ($p<0.05$). Higher a* value on skin side and lower L* value on bone side was measured in RF, CA4 and CA22 as compared to unfrozen-marinated meat ($p<0.05$). RF thawing did not differ from CA4 and CA22 while more redness and darker color was observed in CA4 as compared to CA22 ($p<0.05$). The highest water holding capacity (97.60%) was determined in unfrozen-marinated meat while RF (96.10%) had significantly higher capacity than CA22 (90.20%) ($p<0.05$). RF process, as an innovative and emerging technology, could provide marinated meat of similar quality to unfrozen-marinated meat by minimizing the adverse effect of freeze-thaw process.

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Poster

Effect of non-thermal plasma treatment on structural properties of vital gluten reflecting on its functionality for breadmaking

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Vital gluten (VG) is an ingredient from wheat that is used to improve the technological quality of low-gluten wheat flour. Due to its production process, VG is usually of lower quality than the gluten of the flour that originated it. Non-thermal plasma (NTP) is an emerging technology, which studies have shown that has active species that can affect protein conformation and modify its functionality. In this work, a NTP system operating at 50 W (milder) and 150 W (stronger) power was used, with a flow rate of 5 L/min of argon gas and 10 min of treatment. Analyses to determine the percentage of unextractable protein polymer (% UPP), chemical interactions by solubility in different solvents, free sulfhydryl groups and disulfide bonds, and secondary structure by Fourier transform infrared spectroscopy (FT-IR) were used to evaluate the changes induced in the molecular structure of VG, and how they affect VG when it is developed. Solubility in different solvents, as well as the content of sulfhydryl groups, were altered after NTP treatment. The VGs treated by NTP showed higher solubility in dithiothreitol (DTT) reducing solvent and lower solubility in sodium dodecyl sulfate (SDS) detergent. The FT-IR analysis confirmed the conformational modification of VG, demonstrating the formation of random structures that, when resulting from milder conditions (50 W), were able to recover into more ordered structures when the VG had its gluten network developed, which would result in more elastic and stronger doughs. The unfolding effect of gluten proteins and the formation of aggregates have been suggested. The results confirmed that the treatment of VG with NTP at 50 W with a flow rate of 5 L/min of argon gas and 10 min can change the conformation of gluten proteins and provide more elastic doughs, revealing its potential for improving VG for breadmaking.

Poster

High intensity ultrasound assisted extraction of quercetin from yellow onion peel

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Onion is one of the most widespread vegetables in the world. Its annual production reaches 93 million tons, which 15% are considered waste rich in phenolic compounds, especially quercetin. Among the alternative extraction technologies, high intensity ultrasound assisted extraction (UAE) stands out, being a great alternative for extracting sensitive compounds. Thus, the objective of this work was to optimize UAE parameters to obtain bioactive compounds from onion peels. The extracts were obtained in an ultrasonic probe at 19 kHz for 6 minutes using an ice bath (0 °C) or a thermostatic bath (20 °C). The variables evaluated were ultrasound power (450 W – 150 W), sample/solvent ratio (1:45 – 1:65 g/mL) and type of solvent (99.5% ethanol – 60% ethanol v/v). The extracts were evaluated for overall yield, phenolic compounds, flavonoid content, antioxidant activity and important flavonoids were quantified by HPLC. A kinetic study was performed at optimized conditions. The best condition was compared with maceration, a conventional process. The most suitable condition for obtaining phenolic compounds was 450 W, 60 % ethanol and a solid/liquid ratio of 1:65. However, for the extraction of quercetin, 80 % ethanol was the best solvent, with a difference of approximately 21 % in relation to the maceration. Two main peaks were identified, referring to free quercetin (6.44 mg/g of onion skin) and to quercetin in the glycolyzed form (7.27 mg/g of onion skin). The extraction time was optimized in 5 minutes, indicating that the technique used is significantly faster and more effective than other commonly used. However, after this time, the yield of compounds started to decrease indicating some degradation induced by the process. Extraction performed at 20 °C contributed to increase the overall yield of bioactive compounds, especially quercetin. However, the use of the ice bath was responsible for maintaining the antioxidant activity at higher levels. Despite the higher bioactive yield, the lower antioxidant activities indicate the degradation of secondary at higher temperatures, such as phenolic acids and vitamins. Therefore, UEA proved to be an excellent sustainable technique for extract sensitive compounds with less time and energy demand.

Emerging processes & hurdles technologies

Poster

Unfold the limitation of ohmic heating by mechanistic modelling

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Abstract
Ohmic heating (OH) is one of the emerging technologies allowing volumetric and rapid heating of the product and potentially solving the problem of heat transfer in solid and semi-solid foods. However, particularly, for food products, not only heterogonous in nature but also changes their physical properties drastically during heating is unpredictable. This is a big challenge that limits its application for solid or semi-solid such as meat, baked goods, plant-based food, etc.

This study focuses on a deep understanding of OH processing heterogeneous and changes material properties (physical properties) dramatically during processing. For better understanding and exploring beyond the boundary of its current limit, a mechanistic mathematical model that describes phenomena such as heat and mass transfer (multi-phase, e.g., gas and liquid), electric field, evaporation, and dynamical changes of the physical properties have been developed. The model considers the discrete local variation of material properties. The newly established model is unique to address the challenge of ohmic heating. Model equations (systems of partial and ordinary differential with constitute equations) were solved numerically using COMSOL multiphysics® version 6. Using the modelling, e.g., the pore formation during the processing of meat, plant-based, and baked goods and its effect on the performance of baking/cooking have been investigated. By modelling, new insights have been obtained that shed on how to improve the process performance. The approach has been tested with case and a good agreement between model insights (mechanistic model) and experimental observation has been obtained. At the conference, the mechanistic model, newly obtained insights, and how these can be used to resolve some of the limitations will be discussed. The obtained fundamental understanding can be used for different solid/semi during electric-based processing of solid or semi-solid food.

Emerging processes & hurdles technologies

Poster

Encapsulation of probiotics by water-in-oil membrane emulsification and gelification

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The market for functional foods containing probiotics and bioactive compounds has experienced significant growth in recent years. Health promotion is the main factor contributing to this market. However, viable microorganisms should reach the intestine for effective probiotic activity. Microencapsulation is an alternative to increase microorganism resistance to the product processing and formulation conditions, as well as the migration through the digestive system. Membrane emulsification seems to be an attractive alternative to conventional encapsulation techniques since the pore size of the membrane or filter can control the final size of the microcapsules in addition to the milder process conditions that contribute to the maintenance of bacterial viability. In this study we evaluate the membrane emulsification technique's potential in producing probiotic microcapsules, using different proteins as wall material. Sodium alginate (ALG) and whey protein (WPI), rice protein (RPC), or pea protein (PPC) were tested as encapsulating materials. Encapsulation strategies were based on internal and external gelification. Operating pressure, volume, stirring rate, and polymer concentration were investigated. Emulsions and dried microcapsules were characterized using dynamic laser scattering, optical, and scanning electron microscopy. The best conditions to produce the microcapsules were tested for encapsulation of *Lacticaseibacillus rhamnosus* GG®. The microcapsule diameter varied from 18 to 29 µm and encapsulation yields of around93 % could be obtained. The combination of alginate and whey protein, rice protein, or pea protein improved encapsulation efficiency, resulting in high probiotic viability after simulated gastrointestinal conditions (> 7.18 log CFU g^{-1}).

Emerging processes & hurdles technologies

Poster

Pulsed-electric-field (PEF) application to enhance hydration and amylolytic capacity of wheat and barley during malting process

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Wheat and barley are the most commonly malted cereals worldwide. They have been widely used in different food sectors as starchy ingredient containing important endogenous enzymes such as amylases. Because malting is a time-consuming process, this work proposed the application of pulsed electric field (PEF) technology to enhance the grains hydration by improving the aleurone layer permeability to water and to accelerate the amylase development. For this, a two-step hydration procedure was studied for wheat and barley with an interval of rest under air in-between. PEF treatments (3 kV·cm-1 and total energy applied of 9.9 and 19.8 kJ·kg-1) with 100 or 200 pulses were applied at the beginning or after the first hydration cycle. Using the Weibull exponential model, the first and second hydration curves could be accurately described with a $R^2adj>0.98$ and a $RMSE<0.0092$. The more intense PEF treatments enhanced hydration rate of wheat up to 25% as well as the water holding capacity PEF was applied before the first hydration cycle. Similar behavior was observed when 100 pulses were applied in barley grains, but an enhancement of 10%. The application of 200 pulses in barley grains did not caused any improvement and also caused significant damages to the sprouting process. After drying the post-sprouted cereals for 24 h, the alpha- and beta-amylase activity determined for PEF-treated wheat and barley malts showed up to 2-folds the values found for untreated grains. Both alpha- and beta-amylase could be modulated according to the PEF treatment intensity. Therefore, PEF treatments can be used as a clean emerging technology to enhance wheat and barley hydration step aiming at malting process. Moreover, the proposed PEF-treatments represent viable alternatives to produce malted ingredients not only in a faster way but also with improved functional properties for the most different food applications, as brewery and baking.

Emerging processes & hurdles technologies

Poster

IMPACT OF HIGH-PRESSURE ON THE YIELD AND TECHNOLOGICAL PARAMETERS OF GREEK YOGURT

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The objective of this work was to evaluate the impact of high pressure on yield and technological parameters of Greek yogurt. 20 g of skimmed milk powder were mixed with 1 L pasteurized whole milk. Dairy matrix was treated with different hydrostatic pressures [0.1 (Control), 100, 300, and 500 MPa] for 5?min each, heated at 43 °C, and fermented with Streptococcus thermophilus and Lactobacillus delbrueckii ssp bulgaricus at 43 °C until reaching the pH value in the range 4.5 – 4.6. After coagulation, the yogurt was drained under refrigeration at 4°C for 18 h. Then, milk cream was incorporated at a proportion of 10% (w/w). The yield was calculated by the ratio between the final mass of yogurt and the initial mass of the dairy matrix. The texture analysis of yogurt samples was carried out in a TA - XT2i Texture Analyser (Stable Micro Systems, Godalming, UK). The parameters obtained were hardness, gumminess, and chewiness. Control sample showed a yield of 39.21%±0.77, while samples treated with high pressure had yields of 43.92% ± 2.00 to 100 MPa, 47.50% ± 5.34 to 300 MPa, and 46.42%±4.12. For texture profile, high pressure process promoted the obtaining firmer and creamier samples. Control sample showed hardness of 47.33 g±7.91, while pressurized samples showed values between 162.83 g±14.86 and 209.65 g±47.45. For gumminess and chewiness, control sample has values of 38.48±6.29 and 32.05±3.77, already 100 MPa, 300 MPa, and 500 MPa showed values of 128.32±14.06 and 114.40±13.54, 95.19±8.91 and 87.64±8.12, 122.31±17.73 and 109.57±14.60, respectively. It is notable the improvement in the yield of Greek yogurt production due to the high-pressure process, with increases between 4.71% and 8.29%, when compared to the control. Obtaining yogurts with greater firmness and creaminess is extremely advantageous, since it helps to improve the characteristics of the identity pattern of Greek yogurt. Thus, the application of the high-pressure process prior to fermentation becomes viable for the optimization of the manufacturing process of this dairy product.

Emerging processes & hurdles technologies

Poster

PLASMA ACTIVATED WATER EFFECTS ON FOOD SURFACES

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In recent time Plasma Activated Water (PAW) has been explored for its suitability for fresh food disinfection. Plasma activated water is produced by exposing water to nonthermal plasma and the subsequent transfer of reactive species from the gas phase plasma to the water. Though PAW has been reported to be an effective disinfectant against various food pathogenic microorganisms, information on its stability, process optimization and reactivity with food components is still largely unexplored.
We have designed and tested a continuous flow dielectric barrier discharge PAW generation system and the produced PAW was evaluated for its reactive species on food proteins (whey protein isolate in particular). Mild oxidation of the whey protein isolate and an increase in its solubility was observed upon PAW treatment.
The effectiveness of PAW as a disinfectant was also evaluated for fresh-cut produce washing which was tested on kale and spinach samples as well and fresh cut apple samples. Disinfection of up to 6 log cfu/g of *E. coli* cells on leafy vegetables was observed. Changes in product colour (from the degradation of chlorophyll) were also observed. In the case of cut apples, PAW treatment led to a reduction in the enzymatic activity while it slowed the onset on colour changes (typical browning of apple slices).

Poster

Ultrasonic assisted extraction of Achyrocline satureioides Lam, D.C, (marcela) for enhanced and selective bioactive compound extraction

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Ultrasound Assisted Extraction (UAE) is an emerging sustainable extraction technology which allows to achieve shorter extraction times, reduced organic solvent consumption and lower energy costs in comparison to traditional extraction processes. Application of UAE for revalorization of vegetable material and obtention of enriched bioactive plant extracts is an interesting alternative for this technology.

This work studied UAE to improve aqueous extraction of bioactive compounds from marcela (Achyrocline satureioides Lam.), a native plant from South America. Marcela is rich in flavonols, flavonoids and hydroxycinnamic acids and its extracts could be incorporated in food matrices to increase functional properties and antioxidant potential. It is also consumed as an infusion for the treatment of digestive afflictions and gastrointestinal inflammation. Dried intact marcela inflorescences were extracted using solely water as solvent in an ultrasonic bath, applying 100 and 150 W/L ultrasound power at 40 and 60 °C, respectively. Extraction was followed throughout 30 min by determining antioxidant capacity (AOC) and total polyphenol content (TPC) every 5 min. Extracts were analysed by LC-MS and LC-DAD to identify extracted bioactive compounds and determine the impact of temperature and ultrasound application on compound profile. Traditional solid-liquid extraction at 40 and 60 °C for 30 min were studied as reference extraction methods. UAE extracts were higher in AOC by 140% and 25% at 40 and 60 °C respectively, compared to solid-liquid extraction. For TPC, UAE showed an increase of 110% and 20% at 40 and 60 °C, respectively. LC results indicated that ultrasound application allowed faster and enhanced hydroxycinnamic acids extraction, whereas an increase in temperature resulted in a more diverse compound profile. UAE could be used to extract caffeic acid when applied at 40 °C.

Poster

Profiling Techno-functional and Structural Modifications of Pea Protein by Ultrasound

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Pea is a valuable source of natural protein, as well as other vital nutrients. Ultrasound processing is a non-thermal food processing method in which foods are treated with sound energies. The aim of this study is to investigate the thermal, techno-functional, and structural modifications that occur as a result of treating pea protein isolates (PPI) with ultrasound. Ultrasound treatments were applied at different combinations of time and power levels. Modifications due to thermal changes were analyzed by differential scanning calorimeter. Structural modifications were investigated by FTIR spectrometer and scanning electron microscope, and various laboratory methods were used to examine the techno-functional properties, such as protein solubility. ANOVA simultaneous component analysis (ASCA) established the relationship between the different ultrasound process parameters, while Principal component analysis (PCA) was used to investigate the interrelationships between the modifications impacted by the ultrasound technology. The result shows that, depending on the power level and time of application, ultrasound induced structural change in PPI that enhanced the properties of the products.

Emerging processes & hurdles technologies

Poster

Development and characterization of chitosan-alginate edible films to improve passion fruits shelf-life

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Climacteric fruits, such as passion fruit, have a very short shelf life due to dehydration and intense physiological metabolism, limiting their storage, transport and commercialization. Therefore, this work aimed to produce and characterize chitosan and alginate films to be used as biopolymeric coatings in passion fruits in order to reduce their water loss during shelf-life. Films were produced by casting. The polymer concentration in the filmogenic solutions was 1.5% w/v in the following proportions of alginate:chitosan: 100:0; 25:75; 75:25 and 0:100. Chitosan solutions were prepared in 1%v/v aqueous acetic acid under magnetic stirring for 18h until complete dissolution. The alginate was dissolved in distilled water at 60°C under mechanical agitation at 6,500 rpm. After that, a pre-crosslinking was carried out by adding calcium chloride as a crosslinking agent at 0.5% w/w. In all polymeric solutions, glycerol was added as a plasticizing agent at a concentration of 30% w/w. The polymer solutions were poured in an acrylic plate and dried at 40°C for 16 h. After drying the alginate films were immersed in a crosslinking solution with 1.6 or 3.2 $mgCa^{2+}\bullet cm^{-2}$ alginate film. The films were characterized regarding chemical, mechanical and barrier properties. All the evaluated formulations resulted in non-rigid and homogeneous films. Alginate and chitosan composite films were less transparent than the single films. The film thicknesses ranged from 82 ± 2 to 86 ± 3 µm. Chitosan films were less water soluble than the alginate ones with values of 35.40%± 2.18 and 30.31%± 1.66 for the films with 75 and 100% chitosan, respectively. Films with 75 and 100% alginate were completely water-soluble. However, with the second cross-linking treatment, the alginate films solubility decreased to up to 27%. The sorption degree was in line with the solubility results, i.e., the higher the proportion of chitosan, the lower the sorption degree. Regarding water vapour permeability, chitosan films showed lower vapour permeability than alginate films. Overall, the films produced with higher chitosan concentration showed better potential barrier properties mainly low water solubility and swelling, being suitable for the use in formulations designed to produce edible films or coatings.

Poster

EFFECT OF THE APPLICATION OF LASER PERFORATION ON THE DEHYDRATION OF APPLE SLICES IN REFRACTIVE WINDOW®.

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Refractive window technology (VR) is a novel drying technology, which allows for obtaining high-quality products and presents a high energy efficiency. On the other hand, the application of micro-perforations with CO2 laser is an innovative technology that allows for the improvement of the transfer of matter without cross-contamination. The objective of this research was to evaluate the effect on the antioxidant capacity and total polyphenol content of the application of micro-perforation with CO2 laser technology in the drying of a Granny Smith apple snack in a refractive window.
Apple slices 4 mm thick and 40 mm in diameter were microperforated with a CO2 laser with 3 pore diameters (200, 400, and 600 µm) and 3 pore densities (9, 16, and 25 pores/cm2). Drying in a refractive window was carried out at 70, 80, and 95 °C, in addition, tunnel drying and lyophilization were used as controls. Selected samples were used for an accelerated storage study at 45 °C with a relative humidity of 75%.
The results obtained show that the refractive window at 95 °C presents retention of the properties of the samples without micro perforation similar to the lyophilized, except for the hardness. In addition, the treatment that presents the best result in terms of total polyphenol content and antioxidant capacity corresponds to a configuration that has a drying temperature of 95 °C, a diameter of 600 µm, and/or a pore density of 25 pores/cm2. On the other hand, in storage, this configuration presents a degradation of the antioxidant capacity and the content of total polyphenols, as well as color alteration, more accelerated compared to another configuration. Given the above, a configuration with a low pore diameter and density (200 or 400 µm and 9 pores/cm2), dried at an operating temperature of 70 °C, is an interesting and feasible alternative, since it allows for reducing the time of dried significantly, thus maintaining the properties in terms of color, antioxidant capacity and total polyphenol content after drying and during prolonged storage.

Emerging processes & hurdles technologies

Poster

Radio Frequency Processing of Peanut: Effect of Structure and Particle Size

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Low water activity foods (water activity, aw< 0.85) are regarded to be microbiologically safe, but recent Salmonella outbreaks in these products (eg. peanut butter, tahini) have raised food safety concerns. For the case of peanut butter, decontamination procedures are suggested, but processing the raw material might be a more effective approach.

Radiofrequency (RF) heating is promising thermal processing to reduce safety risks. Therefore, a 10kW, 27.12 MHz staggered through electrode RF system was used to thermal process the peanut samples of different sizes. A water-cooled mill was used to reduce the sample size of the peanut, and 8 different particle sizes (3.55 to 0.28 mm) were obtained by sieving. The oil and moisture content of the peanut samples were 56 and 1.48%, respectively with the aw of 0.28 at room temperature. RF process was applied at different electrode gaps and power levels to determine the optimal process conditions. The target temperature for the samples was to reach over 70 - 80 °C for salted, unsalted, shelled, and unshelled peanut samples. The samples were placed in polypropylene boxes (95×150×75 mm). It took 40 to 50 min at 3500 V for the whole salted-shelled peanuts to reach a surface temperature of 75 °C and for the unsalted-shelled samples to 83 °C. On the other hand, decreasing the particle size increased the heating rate. Within the given process time, samples with a particle size of less than 2 mm reached over 88 °C.

The results demonstrate that the shelled and salted samples reached the target temperature faster than the unshelled and unsalted samples, and particle size was significantly effective. Additional physical mechanisms (eg. turning the product upside down through the process) were noted to improve the temperature uniformity.

The potential of RF heating for thermal processing of peanut as a low moisture food was confirmed, and RF was demonstrated to be potential thermal processing. Additional studies for quality changes and microbial decontamination rates are required to suggest this process for industrial settings.

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Emerging processes & hurdles technologies

Poster

The effect of Cold Atmospheric Plasma treatment on the nutritional quality of leafy greens

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Objective

Cold atmospheric plasma (CAP) is a surface modification technology that has shown extensive promise as a pathogen inactivation technology due to its production of multiple highly reactive products including reactive oxygen and nitrogen species (RONS). RONS inactivate pathogens via oxidative damage to the cell membrane as well as DNA damage. However, this oxidative damage is not restricted to the pathogenic organisms and can result in quality loss in the products treated with CAP. While investigating the interactions of plasma product on leafy greens, we have found that plasma treatment triggers a stress response in plant tissue.

Methods

Leafy greens purchased from a local supermarket were treated by a bench top dielectric barrier discharge (DBD) plasma device (Advanced Plasma Solutions, Malvern Pennsylvania). After treatment, the ROS levels were evaluated using the fluorescein assay (em/ex: 485-525). Flavonoid content was also measured using the diphenylborinic 2-aminoethyl ester (DPBA) assay (em/ex:400/465nm) with epigallocatechin gallate (EGCG) used as the reference compound.

Results

Spinach, red leaf lettuce, and kale all significantly ($p<0.05$) increased their ROS content following CAP treatment, however significant differences were observed in flavonoid content in the three different species. After CAP treatment, flavonoid content in spinach leaves treated with 120 W CAP increased significantly ($p<0.05$) to 3.92 ± 1.83 g EGCG Eq /g. The opposite effect was observed in kale where all treatments resulted in a significant reduction in flavonoid content. No significant difference in flavonoid content was observed in red leaf lettuce compared to control.

Conclusions

CAP treatment of leafy greens appears to trigger the plant stress response system which is still active in plant tissues post-harvest. The products of the stress response appear to differ between species and appear to significantly increase the nutritional value of spinach. Results suggest that different treatment conditions and electrode designs may be needed to preserve leafy green quality while enhancing product safety. Additionally, treatment modifications and innovations in electrode design could enable further nutritional enhancements in these popular and already highly nutritious foods.

Emerging processes & hurdles technologies

Poster

Ultrasonic-assisted pretretment to reduce the content of antinutritional and antitechnological factors of lupin seed flour

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Lupin seeds is considered to be a rich source of protein. In addition, lupine cultivation is better adapted to Mediterranean climate and poor soils than soybeans. However, lupin flour presents a high content of antinutritional (ANF) and antitechnological factors (ATF), such as alkaloids of quinolizidine group, saponins and fat, which could negatively affect the protein digestibility Thus, this works addressed how the ultrasonically-assisted pretreatment of the lupin seed flour affects the content of ANF and ATF.

The extraction solvents used were water and 20% ethanol aqueous solution using a solid/solvent ratio of 1:15 (w/v, g/mL) and a total extraction volume of 200 mL. Conventional and ultrasound extraction processes at two temperatures (and) and two treatment times (3 and 9 min) were carried out. Conventional extraction process was conducted with mechanical agitation (952 rpm). In the ultrasonic-assisted extractions (UAE), the stirrer was replaced by an ultrasonic probe system immersed into the extraction solution and working in cycles of 0.5 s and 790 W/L of power density. After the treatment, the content of ANF and ATF including alkaloids, saponins and fat was measured.

The initial alkaloids, saponins and fat content of the lupin seed flour was g lupine/kg dm, g oleanolic acid/100 g dm and g lipid/ 100 g dm, respectively. In general terms, ultrasonic-assisted extraction led to larger removal of ATF and ANF than conventional one. Thus, using ethanol 20% as solvent during 3 min, the reduction of alkaloids, saponins and fat reached , and , respectively. Therefore, ultrasonic-assisted pretreatment could be considered a feasible technique to remove the content of ANF and ATF of lupin flour. Further investigations should explore how this pretreatment affects the protein loss and stablish an appropriate recovery process.

Emerging processes & hurdles technologies

Poster

UTILIZATION OF AN ECO-FRIENDLY PRESERVATIVE TO IMPROVE THE SHELF LIFE OF "CLEAN LABEL" PAN BREADS

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Obtaining essential oil from Tahiti lime (*Citrus latifolia* Tanaka) juice residue (rinds, seeds) is a way of adding value to this by-product and favoring the circular economy. Due to its antimicrobial activity, lime essential oil (LEO) can be used as an alternative to replace synthetic preservatives in processed foods. Generally, LEO is obtained by cold pressing. However, this method does not present good selectivity and can result in an essential oil with other rind constituents, reducing its antimicrobial activity. Therefore, supercritical CO_2 fractionation (SCF) can be an option to separate volatile compounds of interest, since mild temperatures can be used during this process, preserving thermolabile antimicrobial compounds (e.g., monoterpenes), increasing their preservative potential. Pan bread is increasingly consumed, as it is a practical food. However, it is a highly perishable product (aw > 0.95) and needs the addition of preservatives to enable its commercialization on a large scale. Thus, the main idea of this work was to evaluate and compare the preservative activity of LEO and fractionated LEO (FLEO) to replace calcium propionate in pan bread. For this, eight pan bread formulations were elaborated: CONTROL (C), without preservatives; STANDARD (S), with 0.35% calcium propionate; three with LEO and three with FLEO, each at concentrations of 0.30%, 0.60% and 1.20%. The pan breads were evaluated throughout their shelf life (for water activity, texture, mold, and yeast counts), until counts $>10^4$ CFU/g. Data were submitted to Analysis of Variance (ANOVA), followed by the Tukey test for comparison of means ($p<0.05$) using the software RStudio Desktop 2021.05.18 (version 4.1.0 to Windows). At 0.60% concentration, the natural preservatives doubled ($p<0.05$) the pan breads shelf life compared to the control formulation and presented the same performance ($p>0.05$) as the synthetic preservative until the last day of shelf life, without interfering ($p>0.05$) in water activity and texture of breads. However, FLEO showed no advantages over LEO, suggesting that the SCF process would need to be studied under other conditions. But it was concluded that LEO has potential as a natural preservative in pan bread.

Poster

Evaluation of novel cold plasma treatment to reduce surface fungal colonization of sugar beet roots to improve postharvest storage

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Sugar beet (Beta vulgaris L) is one of the major sources of sugar in the United States of America. It is a major crop grown in Minnesota and North Dakota. Sugar beets are prone to attack by various fungi including *Botrytis, Penicillium,* and *Phoma Betae.* An increase in the respiration rate and accumulation of undesirable invert sugars during storage deteriorates sugar quality and sucrose extraction efficiency. This leads to economic losses during sugar extraction. Approximately 30 lbs. of sugar per ton is lost due to challenges faced during post-harvest storage. To combat fungal infestation, fungicide application is a common mode of operation. However, rising consumer awareness regarding “clean label”, an increase of pesticide and chemical residues in the environment, development of resistant fungal strains has necessitated the usage of novel and sustainable nonthermal technologies. Cold plasma is one such emerging technology. It can offer a non-fungicide approach by deactivating surface colonies of fungal species. Cold plasma involves the generation of plasma (a cocktail of electrons, protons, atoms, and molecules in a metastable state) at lower/ambient temperatures with gases like Argon, carbon dioxide, and nitrogen to create surface modification capabilities without causing major changes in the bulk composition. Plasma has the potential to degrade mycotoxins, damage DNA, and disrupt cellular machinery. Several advantages of this technology include low energy consumption with a reduced energy footprint, applicability at in-line treatments, and being environmentally friendly. This project seeks to evaluate the potential of atmospheric pressure jet plasma and plasma-activated water in decontaminating fungal colonies on the surface of sugar beets at different intensities and periods of exposure. This research will help us analyze the effect of cold plasma on sucrose quality and invert sugar concentration. The treatment could be used either at the farm level after harvest or on a commercial scale where millions of sugar beets are stored after harvest for processing. Since the sugar beet farmers receive a premium based on the sugar content in the beets, this could help the growers and processors improve their profit margin. This will not only boost productivity but also significantly minimize post-harvest losses.

Poster

Application of green coconut pulp in edible ice cream

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The residue from the industrialization of green coconut water, pulp and husk, corresponds to approximately 85 % of the fruit and constitutes solid residue of large volume and slow decomposition. Its use by the coconut water packaging industry would be a sustainable practice and would offer an alternative for other companies to adopt procedures for the treatment and reuse of waste from water extraction. The replacement of milk with green coconut pulp in edible ice cream can be an alternative for consumers who experience discomfort due to low tolerance to milk components, especially lactose. The present work aimed to develop the process of producing edible ice cream through the use of nature green coconut pulp, dehydrated by spray dryer or lyophilization. The influence of the concentration of nature (20 to 41 %) or dehydrated (5 to 10 %) green coconut pulp on the quality of ice creams without the addition of thickeners or emulsifiers was evaluated through the following analyses: overrun, pH , freezing point, melting rate and texture of the products. In products with adequate characteristics, structure analyzes were carried out by means of electron microscopy analyze and of consumer acceptability by sensory analysis. The results obtained showed that it was possible to produce edible ice cream with adequate quality and high acceptability through the use of 25 % of nature pulp or 10 % of pulp dehydrated by spray dryer or by lyophilization. The pulp dehydration process did not significantly affect the quality of the ice cream. It was possible to produce an ice cream with adequate characteristics without the addition of emulsifiers or thickeners through the addition of fresh or dehydrated green coconut pulp due to the functionality of the proteins present in the medium.

Emerging processes & hurdles technologies

Poster

Presentation of the RMT Actia CHLEAN Network

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RMT ACTIA CHLEAN
A unique network in the field of the hygienic design of equipments and the improvement of processes cleaning
The RMT Actia Chlean, coordinated by the CTCPA, brings together thirteen partners in development, transfer, research and education in the field of the hygienic design of equipments : ANSES, INRAE Médis et Umet, BioDyMia, AgroParisTech, Université de St Brieuc, ENIL Mamirolle, Actalia, Adrianor, IFIP, IFV, CRITT PACA and CTCPA.
Pooling their skills, laboratory equipment, and pilot-scale units provide a unique expertise to companies and authorities.
To help food companies improve their performances, taking into account economic and societal changes, in order to:
- control and guarantee food safety and quality while limiting or eliminating the use of preservatives;
- limit the use of chemicals especially during cleaning and disinfection processes;
- diversify food systems and products, which implies more “small” production runs and the need to avoid cross contamination.

The research work is divided into 4 axes led by coordinators from the member structures of the network.
Part 1: The detection of microbiological and chemical contamination.
Part 2: The prevention and correction of microbiological and chemical contamination.
Part 3: The creation of a European network of scientific partners.
Part 4: Dissemination and sharing of know-how.
For 10 years, the RMT has for instance published decision support guides to define good sampling practices and on methods and kits for detecting chemical residues on surfaces, as well as two reference books on hygienic design and antimicrobial agents for companies, students in the agri-food sector.
Joint technological networks are scientific and technical partnerships established and supported by the French Ministry responsible for Agriculture and Food and coordinated by Actia for the food industry.

Emerging processes & hurdles technologies

Poster

NON-THERMAL TECHNOLOGIES - PULSED ELECTRIC FIELD AND HIGH-POWER ULTRASOUND AFFECTS THE ANTHOCYANIN CONTENT IN STRAWBERRY JUICE

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Color is the most important quality characteristic which consumers perceive first in fruit products, as those made of strawberries, especially for juice. Anthocyanins, the antioxidant compounds responsible for appealing red color of strawberries, have unstable chemical structure that decomposes very quickly at elevated temperatures under the conventional preservation methods. Since strawberries are highly perishable fruits and degrade their color easily, a recent study found that processing strawberries with lower ripeness can results in higher quality products with better preservation of anthocyanins. Therefore, the aim of this work was to investigate the influence of non-thermal technologies such as pulsed electric field (PEF) and high-power ultrasound (HPU) on the stability of color, i.e., anthocyanins in strawberry juices. Samples were prepared from fruits of different ripeness levels (75% vs. 100%), and stored for 7 days at 4 ?. The PEF treatment was performed under the following operating conditions: electric field strength (40 and 50 kV), frequency (100 and 200 Hz), pulse duration (0.5 µs), and treatment time (3 and 6 min). The HPU treatment was done under the following conditions: amplitude (25, 50, 75 and 100%), pulse (50 and 100%) and treatment time (5 and 10 min). For fresh juice samples (control samples) and PEF and HPU-treated juices, ripeness and storage had a statistically significant effect on anthocyanin content. Electric field strength and frequency influenced anthocyanins in PEF-samples, while treatment time had no effect. In contrast to PEF, all parameters of HPU treatment (amplitude, pulses and treatment time) had a statistically significant effect on anthocyanin content in juices. Comparing the fresh juice (controls) with the treated juices, a 6.60% increase in anthocyanins was observed for PEF-samples, while the opposite trend was observed for the HPU, i.e., a 10.75% decrease in anthocyanins. In conclusion, strawberries of both ripening stages are suitable for the production of functional juices by non-thermal technologies. The PEF showed a better protective effect in terms of anthocyanins preservation than HPU technology did, hence adjustment of HPU parameters is necessary to explore potential industrial applications.

Emerging processes & hurdles technologies

Poster

Flow-based dielectrophoretic biosensor for detection of bacteriophage MS2 as a foodborne virus surrogate

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A flow-based dielectrophoretic biosensor was designed as a proof-of-concept for the detection of foodborne pathogenic viruses and tested using bacteriophage MS2 as a norovirus surrogate. The flow-based MS2 sensor has two main components: a concentrator and a detector. The concentrator is an interdigitated electrode array designed to impart DEP effects to manipulate viral particles toward the detector in a fluidic channel. The detector is made of a silver electrode coated with polyethylenimine (PEI), single-walled carbon nanotubes (SWCNTs), anti-MS2 IgG, and bovine serum albumin for allowing the antibody-antigen biorecognition events. It is positioned at the end of the fluidic channel and is supplied with electrical current for the purpose of measurement. The fluidic channel and the electrode-supporting layer are made of polydimethylsiloxane (PDMS). Serially diluted MS2 suspensions were continuously injected into the fluidic channel at a 0.1mL/min. A cyclic voltammogram indicated current measurements regarding PEI-SWCNTs coated electrodes increased when in comparison with PEI film surface electrodes. In addition, a drop in the current measurements after antibody immobilization and MS2 capture was observed with the developed electrodes. Antibody immobilization on the biorecognition site provided greater current changes with the antibody-MS2 complexes vs. the assays without antibodies. The electric field applied to the fluidic channel at 10 Vpp and 1 MHz, contributed to an increase of current changes in response to MS2 bound on the detector. The change in current signals presented dependence on the concentrations of MS2 in the sample solution. The proposed biosensor was able to detect MS2 as sensitive as 10^2 PFU/mL with a total assay time of 15 min.

Poster

Optimization of ultrasound extraction of anthocyanins from grape pomace using acidified water as solvent

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Grape pomace is an affordable source of anthocyanins, being ultrasound a non-thermal technology that can assist the extraction of these phenolics. The extraction efficiency depends on process parameters, food matrix, and the extraction solvent. This study aimed to optimize the ultrasound extraction of anthocyanins from grape pomace using acidified water as a solvent. The equipment parameters potency density (8.3 W/mL and 16.7 W/mL), time (1 and 5 min), and pulse (0 and 2 s) were evaluated using a faced centered composite design 23 with 3 center points. Control samples (no ultrasound) were prepared. A 16.7 W/mL ultrasound processor (Eco-sonics®, Brazil) with a 4 mm diameter probe tip was used for sonication. The tip was submerged to a 15 mm depth in the sample. The suspension was prepared with 1.5 g of ground grape pomace (dried at 60 °C for 5 h) and 30 mL of acidified water (pH = 1.5), placed in a jacked glass reactor (internal dimensions: diameter = 45 mm; height = 110 mm) coupled to a thermostatic water bath at 25 °C. Total monomeric anthocyanins (pH differential method) and single anthocyanins by UPLC-QDA (Single ion recording method) were evaluated. Results show that extracts carried out with potency = 16.7 W, time = 5 min, with (2 s) and without (0 s) pulse (no significative difference, $p < 0.05$) presented the highest anthocyanin content, resulting in an extract with up to 48% more monomeric anthocyanin than control. Through the semiquantitative analyses by UPLC-QDA, 14 anthocyanins were identified, comparing their molecular weight and retention time with the literature. Malvidin-monoglucoside and Malvidin-diglucoside were the compounds that presented the highest areas, representing circa 50% of the areas detected. The highest increases observed were 38% for Malvidin-monoglucoside (potency density = 16.7 W/mL, time = 5 min, pulse = 0 s) and 22% Malvidin-diglucoside (potency = 16.7 W/mL, time = 5 min, pulse = 2 s). Higher potency and longer extraction times led to the greatest increase in malvidine-glucosides and monomeric anthocyanins. The results show that acidified water is a promissory solvent to extract anthocyanins using ultrasound, adding value to the grape pomace.

Poster

Effect of cellulose nanofiber from soybean straw on the physicochemical properties of biodegradable films

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Cellulose nanofibers (CNF) are appealing candidates for enhancing the properties of plastic packaging based on natural biopolymers. In this work, CNF were obtained from soybean straw and incorporated as a reinforcing agent in films prepared using different matrices, (type A and B) gelatin, pectin, and chitosan. CNFs were prepared by alkaline treatment followed by enzymatic hydrolysis, mechanical dispersion, and sonication. The films were produced by solution casting and the influence of CNF concentrations (0, 0.5, 1.0, 3.0, and 5.0%, w/w) on morphological, mechanical, and thermal properties were investigated. The CNF and film morphologies were analyzed by atomic force and scanning electron microscopy, respectively. The mechanical properties were determined by uniaxial tensile tests (ASTM method D882-10) and the thermal properties by differential scanning calorimetry. The CNF exhibited fiber morphology with a nanometric diameter (~16.8±1.2 nm) and micrometric length (460-1100 nm). Regardless of CNF concentrations, their incorporation changed the morphology of the films. These films presented air-side drying and cross-sections of heterogeneous surfaces, especially at higher CNF concentrations. The CNF presence decreased the resistance of type-A gelatin (0-5%) and chitosan films at 0.5%. In contrast, the resistance of type-B gelatin and pectin films increased by ~40%, from 1% to 5% CNF. The elongation at break was not affected by the increase of CNF concentration. The behavior observed in type-A gelatin films could be attributed to aggregates formed by CNF/gelatin complex coacervates at preparing conditions (pH<pI= 5.30). For films based on type-B gelatin, pectin, and chitosan, it could be related to electrostatic repulsive interactions between functional groups of the matrix film and CNF, which influences their distribution at different CNF concentrations. On the other hand, the thermal properties of the films were not significatively affected by CNF concentration. The films presented two glass transition temperatures, attributed to plasticizer-rich (glycerol) and biopolymer-rich phases; and the melting temperature, associated with crystals melting. This research enables a further understanding of the effects of CNF concentrations produced by enzymatic hydrolysis on the morphological, mechanical, and thermal properties of biocomposite films; which is of value for future food packaging applications.

Poster

Development of turnip snacks through atmospheric freeze-drying: combination of pulsed electric field pretreatment and ultrasound application

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The production of dried snacks with a high nutritional value represents an alternative to reduce food waste and increase in value production surplus of, for example, turnip. Atmospheric freeze-drying (AFD) is the drying method that better preserves the nutritional properties of food products because it does not entails high temperatures. However, this technique involves long process times. The use of new technologies such as pretreatment with pulsed electric fields (PEF) or the application of ultrasound (US) during drying could contribute to shorten the drying. In this sense, the objective of this work was to assess the effect of different PEF pretreatments and the application of US during AFD of turnip with the aim of producing snacks. For this purpose, 3 mm thick samples of turnip, non-treated (non-PEF) or PEF pretreated were dried at -10 ºC and 1 m/s. Two different conditions were considered for the PEF pretreatments (electric field strength of 1.34 kV/cm, pulse width of 20 µs and frequency of 50 Hz) regarding the number of pulses: a mild treatment of 32 pulses (PEF-M) and a more intense treatment of 1438 pulses (PEF-I). During AFD, US (200 W, 25.9 kHz) were applied through a plate transducer coupled to an atmospheric freeze dryer. The results showed that, the PEF pretreatment did not significantly affect drying time compared with non-PEF samples, regardless the number of pulses applied. However, the application of US during AFD did show a clear increasing of drying rate. Moreover, the combination of PEF pretreatment and US shortened the process, being the shortening greater in PEF-I samples than in PEF-M. Therefore, it could be concluded that the combination of PEF pretreatment and US application significantly enhance the AFD processes of turnip, which could make possible the obtaining of high quality of turnip snacks.

Emerging processes & hurdles technologies

Poster

Cell disintegration index produced by pulsed electric fields (PEF) pretreatment and its influence in the convective drying of butternut

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Convective drying is one of the most used technique in the food industry to dehydrate food. However, there is a need for the industry to overcome the main challenges of the operation: long process times and great energy consumption. Thus, the electroporation of cell membranes generated by the application of pulsed electric fields (PEF) pretreatment could improve mass transfer and thus enhance drying of food product. The most common way to estimate the level of electroporation caused by PEF is through the cell disintegration index (Z), which varies from 0 (untreated sample) to 1 (totally destroyed sample). The aim of this work was to characterize the cell disintegration index of butternut samples caused by different PEF pretreatments and its influence in convective drying kinetics. For this purpose, butternut samples were PEF pretreated at different electric field strength (0.67, 1.34 and 2.00 kV/cm) and number of pulses (between 0 and 1000; pulse width of 20 µS and a frequency of 50 Hz). Z was determined by measuring the conductivity of samples before and after treatment. Once Z was characterized, PEF conditions equivalent to an intermediate level (Z=0.25) and a high level (Z=0.75) of electroporation were considered to apply as PEF pretreatments of drying. In this way, control samples (Z-0) and PEF pretreated samples (Z-25 and Z-75, respectively) were dried at 40 ºC and 1 m/s, recording the weight sample every 5 min.
The results showed that the greater number of pulses and the electric field strength applied, the higher the Z value; reaching values close to Z=1 in the most extreme conditions tested. Regarding the drying, it was observed that the experiments carried out with PEF pretrated samples were shorter than those performed with Z-0 samples. The greater the electroporation, the faster the drying. These results indicate that PEF pretreatment could represent an alternative to enhance the drying process of butternut.

Poster

Properties of soybean oil obtained by pressurized liquid extraction (PLE) in intermittent process using organic solvents: hexane and ethanol

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?New processes have been used to extract vegetable oils in the search for extraction technologies that use green and sustainable solvents. Pressurized Liquid Extraction (PLE) in intermittent process is among these technologies. Physicochemical analyzes were performed to compare crude oils extracted with pressurized hexane (Hex) and ethanol (EtOH) with commercial oil (CO). Density and viscosity were evaluated at 25 and 40°C. The free fatty acid (FFA) content was evaluated using titration with NaOH. For the determination of FFA, the samples were neutralized and saponified, the saponified portion was analyzed by GC-MS. The induced oxidation of the oil was measured by the induction period (IP) exposing the oil to 120°C and air flow of 15L/h. The density did not change, regardless of the solvent. The viscosity of the oil extracted with Hex (47,764 mPa.s and 27,284 mPa.s) was similar to that of CO (49,474 mPa.s at 25°C and 28,407 mPa.s at 40 °C) and was higher than that extracted with EtOH (24,543 mPa.s. s and 14,756 mPa.s). Data at 40°C were lower than 25°C for all samples. The FFA content for the oil extracted with Hex was 2.12±0.02, with EtOH it was 2.11±0.01 and for CO it was 0.32±0.02. The main FFA identified for both oils were linoleic followed by oleic and palmitic. The oil extracted with Hex presented an IP of 8.38h, and the oil extracted with EtOH 0.21h. The CO presented IP 5.66h. The result showed that the extraction methods do not interfere with the oil density. However, the oil extracted with EtOH showed lower viscosity. Oxidation of the oil extracted with EtOH was faster than that of Hex oil. If the acidity was the same for both oils, then the oil extracted with EtOH likely extracts compounds that accelerate oxidation when exposed to oxygen.

Poster

Quantification of vitamin B12 in milk processed by pulsed electric field (PEF), high hydrostatic pressure (HHP), and ultraviolet light (UV-C)

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The deficiency of vitamin B12 (B12) has been regularly pointed out as a public health problem, which affects mainly the elderly. Lack of B12 is associated with leading degenerative damage in the brain, being a risk factor for dementia. Cows' milk is an important source of B12, containing around 0.54 µg of B12/100 g of milk. No conclusive studies have shown the impact of non-thermal technologies such as pulsed electric field (PEF) or high hydrostatic pressure (HHP) on this vitamin, while ultraviolet light (UV-C) is expected to reduce its content.
The objective of this study was to investigate the impact of emerging processes such as PEF, HHP, and UV-C light on vitamin B12 retention in bovine milk.
Raw cows' milk was sourced from a local dairy farm and kept refrigerated prior to processing. Different processing conditions for PEF (16 kV/cm for 8-16 µs), HHP (300-600 MPa for 5 min), and UV-C light (2-18 mJ/cm2 for 2-18 min) were applied for the treatment of cow's milk. Determination of the B12 content was carried out with ultra-performance liquid chromatography-ultraviolet detection (UPLC-UV) at a wavelength of 360 nm.
No significant impact on B12 content in milk was observed for samples subjected to PEF and HHP treatments ($P \geq 0.05$) applied at maximum intensity levels (16 kV/cm for 16 µs, and 600 MPa for 5 min, respectively). By contrast, UV-C light showed a reduction in milk B12 levels when higher UV-C dosages were applied ($P<0.05$), reaching a 10% vitamin loss at 18mJ/cm2 for 16min.
Both HHP and PEF were shown to be appropriate for treating milk, allowing for high retention of vitamin B12 in cow's milk.

Emerging processes & hurdles technologies

Poster

Effect of High-Pressure Homogenization on rheology, sedimentation and colour of Tropical Blended Fruit Juice along the shelf life

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High pressure homogenization (HPH) is a non-thermal technology that has been widely studied as a partial or total substitute for thermal food processing. HPH is able of inactivating enzymes and microorganisms that are responsible for food spoilage, as well as preserving sensory and nutritional characteristics, ensuring quality food production. This study aimed to evaluate the effects of high-pressure homogenization on bioactive compounds, antioxidant capacity and on the physicochemical, physical, and rheological properties of a mixed tropical fruit juice, composed by Cashew, Acerola and Melon. The work was carried out at Embrapa Agroindústria de Alimentos (Rio de Janeiro, RJ, Brazil). The juice was homogenized at pressure levels of 50 MPa and 100 MPa and then compared to the product subjected to pasteurization at 90 ° C / 1 minute, to the juice processed at high hydrostatic pressure at 500 MPa for 10 min. and to juice without treatment. Physicochemical (pH, acidity, soluble solids), total phenolic content, vitamin C, antioxidant capacity and physical stability (particle size distribution, optical microscopy, pulp sedimentation and instrumental color). The juice was kept refrigerated at 4 ° C for a period of 42 days, being the analyzes performed at 0, 14, 28 and 42 days. There was no significant negative effect on pH, phenolic content and antioxidant capacity compared to the control sample, but HPH had negative effect on vitamin C. HPH significantly affected physical stability, causing reduction in particle size, sedimentation stability. and color maintenance in relation to the control. The results obtained in the rheological analysis showed that the juices fit the Herschel-Bulkley model and there was a reduction in juice viscosity with increasing shear stress, as expected. The study indicates that HPH could be a promising technology for improving the quality of the tropical fruit juice along the shelf-life, but further research is necessary mainly regarding microbiological and sensory aspects Keywords: non-thermal process, cashew, acerola, melon, color.

Poster

Recovery of Water and Cleaning Agents from Clean-In-Place (CIP) wastewater using Nanofiltration (NF)-Forward Osmosis (FO)-Direct Contact Membrane Distillation (DCMD): Effects of flow temperature and flow rate

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The recovery of the cleaning agents from Clean-in-Place (CIP) wastewater provides the opportunity to reduce the environmental/economic costs caused by the cleaning operation. The present study proposed Nanofiltration (NF) – Forward Osmosis (FO) – Direct Contact Membrane Distillation (DCMD) to recover the cleaning agents while reclaiming freshwater from the model CIP wastewater. As prefiltration steps, NF was proposed to remove organic residues from the CIP wastewater. After 4 kD and 200 Da NF, the lactose was reduced to a non-detectable level and protein contents were removed by 94%. The permeate from NF prefiltration was further managed by the integrated FO-DCMD. The effects of temperature and flow rate on FO and DCMD were investigated. As the flow rate changed from 500 ml/min to 1500 ml/min, a higher level of water flux could be accomplished for both FO and DCMD. The higher temperature of feed and draw solution was desired to generate a high magnitude of water flux for FO, but the larger temperature gradient between feed and permeate stream was preferred for DCMD. The performances of FO and DCMD were predicted by theoretical models and compared with experimental results. The theoretical models provided close agreement with experimental results. However, the prediction for NF permeates was less accurate due to difficulty in exact estimation for flow characteristics such as viscosity or diffusion rate. During continual concentrating of the NF permeate, the prediction of FO using the theoretical model was not accurate due to fouling formation onto membrane surface that could be attributed to high-temperature operation in feed and draw solution stream. However, the FO-DCMD could accomplish the recovery of high quality water without salts contents. In addition, the cleaning efficacy of the cleaning agents recovered by NF-FO-DCMD was proven to be comparable to the fresh one by a Quartz Crystal Microbalance with Dissipation monitoring (QCM-D).

Emerging processes & hurdles technologies

Poster

Effect of ultrasound on fermentation kinetics and quality of buffalo yogurt

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Milk fermentation is a slow and expensive process, requiring the maintenance of milk for a long period at 43ºC for bacterial growth. Yogurt defects, such as gel breakage and syneresis, may limit the product shelf life. Ultrasound (US) can be used to overcome these barriers, due the potential of this technology to improve the fermentation and quality of fermented products. Thus, this study aimed to evaluate the effect of US on the fermentation parameters of buffalo milk and on the characteristics of the yogurt obtained after 1 and 21 days of storage. Milk (with or without 5% sugar) was fermented partially (1, 2, or 3h) or fully (7h) under US (25 kHz, with 38W/L volumetric power) and then stored for 21 days at 7ºC. The results showed that US-assisted fermentation was effective in accelerating the fermentation rate (up to 41% increase), reducing the fermentation time (up to 2 hours), as well as improving the quality attributes of buffalo yogurt when compared to conventional fermentation. The samples produced by US-assisted fermentation, with or without sugar, did not show differences in pH, acidity, and lactic acid bacteria viability when compared to the control sample ($p>0.05$); however, those fermented for 1h and 2h under US had increases in water holding capacity (up to 35%), consistency index (up to 81.1%), and apparent viscosity (up to 69.4% with a shear rate at 10s-1) ($p<0.05$), resulting in more consistent gels, as evidenced by microscopy images. On the other hand, samples subjected to long US-assisted fermentation (≥ 3h) had a more fragile structure, with a consistence index and apparent viscosity similar (3h of US) or lower (full fermentation under US) than the control sample ($p<0.05$), also impacting the water holding capacity. Finally, the addition of sucrose contributed positively to the quality attributes of the yogurt, allowing the formation of a gel with a more compact protein network. Based on these results, we concluded that partially US-assisted fermentation can be an interesting strategy to accelerate the process and improve the quality of buffalo yogurt.

Poster

Impact of ultrasound and protease addition on the fermentation profile and final characteristics of fermented goat and sheep cheese whey

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Goat cheese whey (GCW) and sheep cheese whey (SCW) is a by-product usually destined for animal feed or improperly disposed in smallholdings, reducing the income of artisanal producers, and causing a negative environmental impact. Fermentation can improve the sensory/nutritional characteristics of goat (GCW) and sheep cheese whey (SCW); however, the limited nutrients availability for lactic acid bacteria (LAB) growth and the low stability of whey are challenges. To overcome these challenges, this project aimed to: (i) evaluate the GCW and SCW fermentation parameters under US, with or without proteases, and (ii) characterize the obtained products (up to 28 days of storage at 7ºC) regarding LAB count, physicochemical characteristics, structural stability, and in vitro antioxidant activity. The results showed that the processes were able to increase the rate of pH decline in SCW (23-32%), when compared to traditional fermentation. The evaluation of the physical stability of fermented GCW and SCW showed that both products were destabilized, with cream (up to 60%) and translucid whey (up to 80%) separation during the shelf life of the products. However, the rate and way of destabilization (formation of cream, translucid whey, or both) was different between samples ($p<0.05$) due to partial hydrolysis of proteins (caused by protease), reduction of fat globule size (induced by US) and their interactions. The micrographs of proteins in the samples help to explain the observed phenomena. Regarding the LAB counts, there was a reduction during storage (1.5-3.0 log CFU/mL), caused by nutrient depletion and low tolerance at pH ~4.0, reached due to post acidification. For the in vitro antioxidant activities of the ABTS radical, it was observed an increase for the SCW (up to 40%) and GCW (up to 30%) samples during storage, when compared to unfermented whey. Therefore, US-assisted fermentation and the addition of proteases could be interesting interventions to improve the pH decline rate in whey fermentation and can be strategically used to change the way that samples will destabilize. Further studies should access the impact of these interventions, associated with the addition of stabilizers and nutritional supplementation on the structure and LAB viability in GCW and SCW.

Poster

Ultrasound assisted technology as technological tool for obtaining Sacha Inchi proteins

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Poster

The effect of raw materials composition and extrusion parameters on the texture properties of high-moisture meat analogs made of faba bean, yellow pea, and soybean protein concentrates and their mixtures

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The transition toward more sustainable diets with a higher intake of plant-based foods has been identified as a crucial factor in improving health and reducing the environmental burden on the current food system. A vital role in this growth has been played by manufacturers' attempts to meet consumer expectations of meat-like products and thus gain acceptance through utilizing extrusion cooking technology. While soybean has dominated the scene of meat analogs since its evolution because of its nutrition and functional properties, faba bean and yellow pea exhibited a high potential to replace soybean due to their high nutrition, availability for good practice cultivation, and functional properties. This study investigates the effect of extrusion parameters and altering raw material composition on the texture of High-Moisture Meat Analogs (HMMAs) made from faba bean, yellow pea, and soybean protein concentrates and their mixtures using an Augmented Simplex Centroid (ASC) design of experiment. The most important elements influencing the textural qualities of meat analog were identified. The ash, fiber, and protein content, as well as the source protein's water-holding capacity, had the most significant impact on the textural qualities of the HMMAs. Three extrusion process parameters were investigated in the preliminary trials (target moisture content, extrusion temperature, and screw speed), and two extrusion process parameters were examined in the main experiments (target moisture content and screw speed). The extrusion process parameters significantly affected the texture of HMMAs. In conclusion, it is possible to manufacture texturized HMMAs from faba bean or yellow pea protein concentrates by replacing the soy with different ratios giving a wide variety of texturization properties and qualities that can be utilized commercially as complete meat muscle-like cuts; chicken-, red meat-, or fish-like products or other processed meat analogs.

Emerging processes & hurdles technologies

Poster

PEF assisted thermal inactivation of Bacillus coagulans in peach puree – Process optimization

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Objective
Bacillus coagulans is a heat resistant bacterium of significant concern for acid processed foods. It is responsible for causing "flat sour" spoilage in canned vegetables and fruit products (pH-value<4.2), due to the production of lactic acid. Thus, its inactivation is a key safety target for the relevant industries. The application of pulsed electric fields (PEF) in combination with heat has been already recommended as a new non-thermal pasteurization method of fruit juices, since it enables spore inactivation with lower heat load compared to the conventional thermal processes, while minimally affecting the quality of final products. The efficacy of combined PEF treatment with heat was evaluated for the inactivation of Bacillus coagulans spores in peach puree.

Methods
Bacillus coagulans (provided by Greek leader company in fruit concentrates production) (107 CFU/mL) were suspended in sterile distilled water and in peach puree (pH equal to 3.7). The samples were subjected to different PEF (2-10 kV/cm, 0.01- 1 s, 50 Hz, 10 μs pulse width) process conditions under various preheating temperatures (<30, 55, 65 and 75 °C). PEF process conditions were evaluated in terms of their effectiveness in inactivating B. coagulans at as low temperatures as possible. Process optimization was also conducted using appropriate empirical mathematical equations. Selected quality parameters of PEF treated samples such as Brix, pH, color, viscosity and sensory evaluation were also studied in comparison to only heat-treated samples.

Results
PEF treatment at preheating temperatures below 30 °C showed no significant inactivation for B. coagulans in both media. More intense PEF conditions resulted also to quality degradation of the peach puree. Inactivation of all cells was observed at temperatures 75 °C and 10 kV/cm. No effect was observed in the cells inactivation for the only heat treatment at the same temperature.

Conclusions
The results obtained show that PEF-assisted heat pasteurization at selected conditions could be applied for the production of purees free from B. coagulans cells, positively affecting the shelf life and quality of the products.

Poster

Cold Atmospheric Plasma Processing for Quality Retention and Shelf-life Extension of Plant Foods

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Cold atmospheric plasma (CAP) has emerged as a potential alternative to traditional methods for food decontamination, minimally affecting food quality. Depending on food treated, CAP could be applied on foods directly through activated gas flow, semi-directly through reactive oxygen and nitrogen species (RONs) diffusion on the surface of the food or indirectly through food immersion in plasma activated water (PAW) in which RONs are generated.
In a closed rectangular reactor, Surface Dielectric Barrier Discharge was applied (2-3 kV, 32-42 kHz, 5-20 min) for fresh strawberries (Fragaria Ananassa cv ELSANTA), fresh pistachio (cv. Aegina) and a ready-to-eat (RTE) rocket salad. A CAP jet (0.5-3 kV, 80-85 kHz, 0-30 min, Helium 0.5-5 L/min) was used to i) activate water (PAW) to be used as a RTE salad washing agent and ii) to directly process freshly squeezed orange juice. For all products, their main quality parameters were evaluated immediately after processing or/and during their shelf-life.
SDBD led to total viable count (TVC) inactivation in strawberries by ~1.0 logCFU/g, resulting in lower microbial load during storage compared to Control. The quality was enhanced as derived from the increased trends in antioxidant activity and ascorbic acid, while the activity of pectin-methylesterase (PME) remained lower compared to Control. Correspondingly, TVC load of pistachio was reduced by ~0.7 logCFU/g after CAP, resulting also in no aflatoxin detection, in contrary to Control. A TVC reduction of ~0.5-1 log CFU/g was observed for the RTE rocket, depending on the processing conditions. Processing time of 10 min was considered as the optimum, for a satisfactory TVC reduction and quality retention. Direct CAP resulted in orange juices PME inactivation, with increased rates at higher voltages, leading to residual activities ranging from 15-35%. Regarding CAP indirect use, increase of the immersion time of RTE rocket in PAW led to TVC decrease (by up to 2.0 logCFU/g) and partial degradation of the color and texture. Immersion time of 10 min was considered as the optimum for a satisfactory reduction of microbial load and quality retention.
The results obtained validate the efficiency of CAP in producing plant foods of high quality and longer shelf-life.

Poster

Influence of time-temperature interactions on physicochemical attributes and microbiological safety of traditional buffalo meat dishes

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The present work aimed to study the time-temperature interaction effect on the physicochemical characteristics and microbiological safety parameters of buffalo meat dishes at the household level. Two minced meat dishes, Keema, and meatballs, and one meat cubes dish, stewed meat, prepared according to the authentic traditional recipe. The microbiological parameters (total aerobic count, total coliform count, Staphylococcus aureus count, lactic acid bacteria) and physicochemical (pH, titratable acidity, water activity) were studied. Results indicated that all meat dishes meet the international reference time-temperature duration for ensuring food safety (65 ?C for 15 min). Initially, raw meat had a total aerobic count of 5.12 ± 0.16(log10 cfu/g), whereas, after cooking, the value was reduced considerably, even though the higher count was detected in Keema at 1.93 ± 0.15 (log10 cfu/g) while lower was in meatballs 1.25 ± 0.18 (log10 cfu/g). Likewise, a higher total coliform count was detected in Keema dish 0.67 ± 0.22 (log10 cfu/g), while the lowest was found in stewed meat dish 0.37 ± 0.24 (log10 cfu/g). Lactic acid bacteria, yeast, and Staph. aureus count was not detected in cooked buffalo meat dishes. Results regarding pH, water activity (aw), and titratable acidity were in the range of 5.53±0.07 to 5.69±0.09, 0.88±0.08 to 0.94±0.27, and 0.69 ± 0.11 to 0.78 ± 0.19%, respectively. Meatballs have higher pH and water activity values, while meat cubes have higher titratable acidity. This study suggests that adopting hygienic practices and avoiding cross-contamination could prolong the shelf life of dishes.

Poster

Jabuticaba (Plinia cauliflora) peel as a source of pectin: comparative evaluation of extraction methods

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Jabuticaba (Plinia cauliflora) is a small fruit native to Brazil and its peel is a source of antioxidants and soluble dietary fibers. In this study, the fruit peels were dryed and ground, and the resulting flours were evaluated as a source of pectin. Four different extraction methods using ultrasound (US) coupled to microwave heating (MW) and/or enzyme treatment were employed: US extraction followed by low temperature heating (40 °C): (i) in microwave (MW) (3 min) without (method 1) or with cellulase (method 2) or hemicellulase (method 3); or (ii) in a water bath for 5 hours (method 4). Precipitation, washing, drying, grinding and sieving steps completed the processing. The obtained pectins were characterized in terms of their carbohydrate and phenolic profiles. Yields ranged from approximately 18% for methods 1 (US+MW) and 4 (US + water bath heating) up to 22% for US-MW-enzyme assisted extractions (methods 2 and 3). The methods that did not employ enzyme extraction provided low methoxyl pectins, as opposed to high methoxyl pectins obtained after enzyme treatment. MW and water extraction had similar performances. Different neutral sugars were identified in the extracted pectins, in addition to cyanidin-3-O-glucoside and ellagic acid. Cyanidin-3-O-glucoside (C3G) and ellagic acid were the main phenolic compounds found in jabuticaba peel flours, with the C3G content ranging from 104.31 to 176.77 mg/100g, with the higher levels associated to enzyme-free treatments (methods 1 and 4). All pectins from jabuticaba peel presented a reddish tone, good emulsifying properties and high swelling capacity. The pectin extracted using US+MW+hemicellulase (method 3) was the one that presented better emulsifying performance (higher values of emulsifying activity and emulsion stability), being actually more effective than commercially available citrus pectin.

Poster

Impact of pulsed electric field (PEF) intensity on cream yield, overrun, stability, and protein components

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New applications from altering structural components in dairy food could be enabled by the use of pulsed electric fields (PEF), ideally, retaining the native character of the dairy product. The effect of PEF intensity on the fat separation from bovine raw milk following centrifugation was studied regarding yield, overrun, stability and protein components in the resulting cream.

PEF treatment was conducted with refrigerated raw milk, using a continuous-flow co-current treatment chamber with electric field strengths ranging from 9 to 27 kV/cm for a treatment time of 33 µs. Prior to skimming PEF-treated milk was heated to 40°C. Cream was analysed regarding yield and fat content (Milkoscan), overrun (high-shear mixer) and stability (centrifugation) after 20 and 60 s, and protein components (gel electrophoresis).

Cream yield increased ($P<0.05$) for milk PEF-treated at 21 kV/cm and below considering the total amount of fat removed from the skimmed milk. However, no significant differences were observed for the fat content when comparing cream from untreated and PEF-treated milk fat globules ($P\geq0.05$). PEF treatments also influenced the overrun of the produced cream, with the most intense treatment at 27 kV/cm decreasing the overrun capacity, whereas the mildest treatment at 9 kV/cm increased it by 30% compared to cream that was not treated with PEF ($P<0.05$) at 20 s. At 60 s an increased overrun was observed from 9 to 21 kV/cm, achieving an overrun up to 65% greater for the least intense PEF treatment conditions than for untreated cream ($P<0.05$). Moreover, the stability analyses of the cream showed a stronger cohesion induced by the most intense exposure to PEF. Milk protein banding on non-reduced and reduced gels remained unchanged after PEF, but for PEF-treated cream the quantity of protein bands decreased slightly.

Processing raw milk with PEF at different intensities followed by milk separation for cream production produced a higher yield in cream without affecting the fat content. Different PEF intensities enabled tailored cream overrun and stability for industrial applications. Milk protein components subjected to PEF did not change regardless of the applied intensity, but subsequent heating and separation induced changes in protein structure of cream.

Emerging processes & hurdles technologies

Poster

Fabrication, characterization, and potential applications of texturization of biopolymers to produce nutritious and high-quality food products

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Texturization of proteins and other food molecules has become a useful processing tool for creating foods with improved textures and nutritional qualities. There is an increasing interest in using plant proteins to produce meat analogs which are promoted by environmental, health, and sustainability concerns. However, the amino acid composition of plant proteins and their reduced functionality may limit their applications in the manufacture of quality foods. It is being considered that the structuring of vegetable proteins and other food components will favor various food applications. Therefore, a systematic and in-depth understanding of the texturizing mechanisms and how the physicochemical properties of raw materials affect the final quality of the product is necessary.
Key parameters that are associated with the texturization of proteins and other food components, which are closely related to changes in the protein structure and interactions with other components will be discussed. Different types of manufacturing processes, their process conditions, the type of raw materials and their physicochemical characteristics, and their effects on the product quality will be described.
Extrusion is one of the technologies used for protein texturing. Distinctive features of extrusion technologies currently used and under development and their different capabilities will be discussed and linked to the development of innovative food products. The role of formulations in product rheology and their effects on product quality shall be described.
The presentation will focus on the fabrication of structures from plant and animal proteins and other materials via self-assembly, electrospinning, solution blow spinning, 3D printing, wet spinning, and high-temperature shear for several applications where such food materials assemble in quality foods.

Poster

Effect of high-power ultrasound as an emerging technology for vegetable oil bleaching

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In Mexico, canola (*Brassica napus* L.) is positioned as the most used oilseed for vegetable oil extraction, because it is rich in poly and monounsaturated fatty acids such as linoleic acid (21%) and oleic acid (61%). However, for these to be preserved intact in it, it is necessary that the bleaching method does not modify their *cis* configurations. Since the method currently used for its realization has the disadvantages of using high temperatures (100 °C), a long processing time (180 min) and a high percentage of bleaching clay (3%), which may favor the appearance of *trans* configurations, the aim of this research was to develop a bleaching methodology for canola oil, using high-power ultrasound (40 kHz-600 W) applied in 9 treatments in which the processing time was varied (60, 75 and 90 min), the percentage of clay (1, 2 and 3%) and its temperature (60 and 80 °C). Evaluating the content of chlorophyll *a* and *b* (µg/100 g), carotenoids (µg B-carotene/100 g), color (L*, a* and b*) and, finally, performing a spectroscopic analysis. These samples were evaluated with in a control treatment (conventional bleaching treatment). The results showed that the ultrasonic treatments that used 60 and 90 min with 2% clay at 60 °C, reduced the highest amount of chlorophyll compounds (98% approximate). On the other hand, regarding the reduction of carotenoids, these same treatments showed a similar trend to the conventional method (30% reduction). These results were reflected in the color of the samples, where the ultrasonic samples presented the lowest values ??in a* and b*, as well as being more luminous (high L*). Finally, the spectroscopic analysis did not show the appearance of *trans* configurations. In this sense, high-power ultrasound can be widely considered as an effective tool for bleaching vegetable oils, which helps to optimize the resources used in the process.

Emerging processes & hurdles technologies

Poster

Uvaia (Eugenia pyriformis) fruit: a new source of phenolics compounds obtained by Pressurized Liquid Extraction (PLE)

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Uvaia (Eugenia pyriformis) is a Brazilian native fruit with great economic potential due to its excellent nutritional composition rich in phenolic compounds. Conventional extractions involve severe time-temperatures conditions and processing time resulting in partial bioactive compound degradation. In addition, the high amounts of solvents used makes this extraction not ecofriendly. Thus, alternative extraction methods, including pressurized liquid extraction (PLE), have been highlighted in obtaining bioactive compounds from plant matrices. This study aimed to obtain uvaia pulp extracts rich in phenolics and flavonoids compounds by PLE. The extraction was realized keeping the pressure constant at 10MPa. Extraction time was defined through extraction kinetics (100 ºC, 1.71 mL.min-1, 150 min). The best extraction condition was evaluated through a 2^2 rotational central composite design (DCCR). The effect of temperature (40 to 100 ºC) and percentage of co-solvent (ethanol) (60 to 99.5 %) on the content of phenolic compounds and flavonoids were evaluated. Extraction kinetics showed that extraction yield remained almost constant after 60 minutes. The total of phenolics and flavonoids ranged from 4.91 to 17.00 (mg GA .g-1 of dry uvaia pulp) and 2.19 to 7.91 (mg CAE.g-1 of dry uvaia pulp), respectively. The predicted extraction model showed that both temperature and solvent influence the phenolic extraction and the optimized condition was observed at 55 ºC and 70.0 % of ethanol. The presence of ethanol improves the extraction selectivity and the high temperature enable the breakdown of the linkages between bioactive and uvaia pulp matrix. Conversely, for flavonoids extraction high solvent concentrations and high temperature negatively affected the extraction. The antioxidant activity for extracts was 189,72 ± 10,34 µM Trolox.g-1 of dry uvaia pulp and 231,41 ± 10,96 µM Trolox.g-1 of dry uvaia pulp for phenolics and flavonoids, respectively. The results show that uvaia pulps is a rich bioactive source and PLE is an efficient method for its extraction.

Emerging processes & hurdles technologies

Poster

Colon-targeted delivery of probiotics through millet-pulse based synbiotic nutrisnacks using an encapsulation-3D printing approach

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Objective:
Probiotics can support a healthy life when administered in an adequate amount. It can be delivered as food and supplements, are generally considered as functional foods. The focus of this research was to study the feasibility of delivering the probiotics through a synergistic approach of encapsulation and 3D printing processes.

Methods:
Probiotics were encapsulated using a spray-freeze drying (SFD) method with prebiotics. Further, the synbiotic powders were mixed with protein-fiber-rich composite flour and 3D printed as synbiotic-composite flour nutrisnacks and then treated post-processed using freeze drying (FD) method. The probiotics' viability after 3D printing and post-processing was assessed for both raw and roasted composite flour matrix to analyze the impact of pre-treatment on the viability of probiotics and starch digestibility. The delivery of encapsulated probiotics was validated using an engineered dynamic in vitro digestion model ARK® and compared with the simulated static in vitro digestion process.

Results:
Roasting pre-treatment of composite flour does not have any significant implications on probiotics viability during printing and post-processing. Whereas, the post-processing method has a significant effect on probiotics viability. The roasted composite flour snacks had a higher starch digestibility index (13.77%) as compared with raw composite flour snacks (8.11%). It indicates that the digestibility of synbiotic flour made with 3D printing snacks was improved by the implementation of roasting process. The results of comparative analysis of static and dynamic digestion showed significant differences. In each digestion method, a significant difference was found between SFD and free cells, but no significance was found in terms of roasted and raw composite flour.

Conclusions:
Overall, a synergistic approach of encapsulation and 3D printing processes resulted in higher viability (8.18 ± 0.28 log10CFU/ml) and better survivability (79%) of probiotics. In the dynamic digestion study, the stability of administered probiotics till the termination of the ileum section in the small intestine showed the targeted delivery of probiotics. Thus the results showed a synergistic approach of encapsulation and 3D printing processes promising the delivery of probiotics at a targeted site of action.

Emerging processes & hurdles technologies

Poster

3D printing of banana incorporated pearl millet snack

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Objective:
3D printing is a promising method to create foods with specialised nutrients. This research investigated the potential of 3D printing for the creation of a snack product using pearl millet flour (PMF) with an alternative natively non-printable ingredient, ripe banana (RB).
Methods:
The material supply (dough) combinations with 52 and 55% w.b. moisture content (100:0, 80:20, 60:40, 40:60, 20:80, 0:100 PMF: RB) were analysed for the physical, mechanical and physiochemical parameters. Printability studies were conducted to optimize the printing speed (600, 800, 1000 mm/min), motor speed (120, 180, 240 rpm) and nozzle diameter (1.22, 1.56 mm) at constant pressure (up to 3 bar). Optimised 3D printed constructs were evaluated by sensory panellists based on their binding property, layer definition, etc. The printed constructs are post- processed by steaming (10 min) and microwave cooking (540 W; 3 min) and the sensory analysis was conducted to evaluate the consumer preference.
Results:
All the material supply combinations were observed to be shear thinning (n=0.16-0.67). The total colour difference E values were ranged from 1.56 to 17.46 during banana incorporation. Water activity and bulk density of material marginally reduced with increase in quantity of banana. Values for gumminess, chewiness, cohesiveness, and springiness are increased when hardness is reduced during the banana incorporation. Three combinations (100:0, 80:20, 60:40 PMF: RB) are printed with high layer definition and precision. In addition, incorporation of banana resulted in an increase in fats (1.23-4.68 g/100g), ash (0.78-0.95 g/100g) and a decrease in protein (4.2-3.7 g/100g) content. Based on the sensory score, the optimized condition for printing the constructs is as follows; 600 mm/min printing speed; 240 rpm motor speed; 1.22 mm nozzle. Sensory attributes were more favourable to microwave-cooked snacks.
Conclusions:
This study gives the fundamental understanding of the role of 3D printing in producing millets-based snacks. It would be the foundation for 3D printing technology with an emphasis on development of highly nutritious foods with improved consumer acceptance.

Sustainability, food chain & decarbonisation

Oral

Potential of polysaccharides for food packaging applications

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Food packaging accounts for more than 50% of the global market for fossil fuel-derived plastic packaging and is the fastest growing sector of this market. However, in recent years, their use has become a major concern for the environment. The extensive use of plastics and the lack of proper recycling systems have led to an estimated accumulation (from 1950 to 2015) of about 4.9 billion tons of waste in landfills and water bodies worldwide. As a result, recent strategies have been implemented globally with the aim of reducing dependence on fuel-based feedstock, increasing the recyclability of plastics, and reducing plastic leakage into the environment. Sustainable packaging is also an area of research and innovation that is necessary today. Many investigations are based on materials that come from biological sources and can be used as substitutes for conventional plastics to produce biodegradable and/or recyclable packaging. Both proteins and polysaccharides have good film-forming properties. However, proteins generally find higher value-added applications as food or feed ingredients. For the present study, different types of polysaccharides from different sources were selected to provide a broad overview of the main physicochemical properties of polysaccharides under standardized conditions for their applications in food packaging. Their performances were evaluated as film-forming solutions and as self-standing films, especially for barrier, mechanical and optical properties. In addition, an aging test was performed to characterize the evolution of these properties under different storage conditions, in order to evaluate their long-term stability. The use of some of these polysaccharides as coatings for paper-based packaging, as well as the development of multilayer packaging, are suggested as the most promising applications. The biodegradability of polysaccharides also offers an alternative waste treatment route for these applications where recycling is not technically or economically feasible.

Oral

Innovative encapsulation strategy to improve sustainability of biodegradable bioactive food packaging: case of PHBV (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) containing carvacrol.

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Increasing sustainability of the food chain means tackling, among others, the negative impacts of packaging material, especially those linked to persistent plastic packaging, while reinforcing the positive impact of packaging, which is food quality preservation and food loss and waste mitigating prevention. To reach this goal, one solution is to use biobased (but nonfood or nonfeed sourced), bioprocessed, biodegradable and bioactive packaging. Bioactive means that a natural compound is added to the polymer to enhance its ability to preserve food and extend shelf-life while the intrinsic biodegradability of the polymer is maintained. In this context, (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) is a good candidate as polymer as a biosourced, bioprocessed and biodegradable molecule, and carvacrol is a good active molecule candidate, as it has a strong antimicrobial effect. However, carvacrol is also volatile and heat-sensitive, and encapsulation is necessary to avoid a loss of the molecule during the thermal formulation process of the packaging and during packaging storage. On the other hand, encapsulation must not hamper the release of the active compound when needed, i.e., in contact with food. Finally, adding an active compound must not modify biodegradation kinetic; therefore, a strategy is to apply encapsulated carvacrol on the packaging surface in a thin coating layer.
In this context, this work aimed to encapsulate carvacrol in PHBV (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) nanoparticle - intended to be deposited on the packaging surface - and to study the carvacrol release kinetic during storage. To do that, a nanoprecipitation method was adapted to shape PHBV nanoparticles. For instance, the molar mass of PHBV must be necessary below (150 kDa) to successfully obtain nanoparticles (SEM observations). Then encapsulation was characterized, and the release of carvacrol from the nanoparticles powder/material coated with PHBV nanoparticles was studied. A model describing the molecular diffusion using the second Fick's law was developed and adjusted to experimental release data, with a good fitting. Such a model would permit us to anticipate the dimensioning of such active packaging as a function of food requirements (e.g., antimicrobial compound concentration in the headspace, for instance).

Sustainability, food chain & decarbonisation

Oral

Using time equivalence to design safe recycled food packaging with functional barriers

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Context & Goals

European "single-use" Directive 2019/904 and French "anti-waste" Law N°2020-105 have programmed the forthcoming end of single-use plastics, including food packaging. Still, plastics other than PET are not widely recycled for food contact due to safety concerns. Using recycled materials behind a virgin layer called functional barrier (FB) could resolve the issue under specific provisions. Still, neither the European regulation nor the FDA offer guidance concerning functional barriers evaluation and use. This study aims to give rules to risk assess FBs with non-authorized recycled materials in contact with food by seeking same protection with authorized virgin monolayers. This new approach goes beyond toxicological thresholds in order to discuss whether the use of a FB can overcome decontamination problems of recycled plastics other than PET or not.

Approaches

Mathematical modeling is the only viable method recognized by European and American agencies to evaluate recycled material under usage conditions. Compliant numerical diffusion models are used to simulate homologous aromatic solutes diffusion in relevant systems with recycled polypropylene and glassy virgin polymers known to have good barrier properties such as rPP/vPET or rPP/EVOH/PE multilayers. The conditions and parameters of the simulations are chosen under conservative assumptions and diffusion coefficients are extracted from validated data or measured independently by sorption or stacking experiments. The dimensionless approach of the problem makes it applicable to any type of plastic packaging, geometry, substance, application.

Main results

The feasibility of lowering decontamination behind a FB for materials difficult to decontaminate or with a less controlled origin is demonstrated: low molecular weight contaminants are easily removed but not stopped by the FB, whereas high molecular weight contaminants are persistent but easily stopped by a glassy layer. An optimal decontamination profile for PET and EVOH barriers is proposed and experimentally validated. Risk assessment and substance-dependency rules are identified for functional barriers and homologous organic contaminants. The thickness of the FB needs to be sufficient to accommodate food shelf-life and the storage of the material before use. Considering this, multicriteria optimization offers good prototype for food packaging combining maximized shelf life and minimized amount of virgin polymer.

Sustainability, food chain & decarbonisation

Oral

Development of effective permeance relationships for ethylene losses from packaging systems.

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Physiological changes in fruit can be influenced by the within packaging ethylene microenvironment created by the fruit and the losses through the film. Predicting ethylene concentrations profiles within packaging systems may help in packaging perforation design to minimize ethylene accumulation. Predicting the concentration profile for a packaging system needs to consider the transfer through different features that a package may have, such as holes, folds or micro-perforations. Prediction of gas within packaging microenvironments has been well established for micro-perforations but there are less robust models for larger features, with the assumption usually being that there is no meaningful profile. The objective of this study was to establish the dimensional bounds of packaging and when an effective permeance model is appropriate (assuming uniform internal package concentration). Simulations were conducted using COMSOL for ethylene gas loss from a range of different packaging scenarios with large holes and folds and with ethylene sources at different locations within the package. Based on the simulations, simplified effective permeabilities to account for gas losses through holes and folds were developed and related to their geometry. The Finite Element Model and effective permeance models were compared with experimental data.
The effective permeance relationships created in this study could be used for a range of gas systems with uniform internal package concentrations.

Keywords: Ethylene, plastics, supply chain, fruit loss, packaging, shelf-life

Sustainability, food chain & decarbonisation

Oral

Microscopic model mass transfer of contaminants from recycled paper and board into foodstuffs

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Goals

Food packaging made of recycled cellulosic materials is a systematic source of aliphatic and aromatic mineral oils (MOA). Almost all MOA are potentially carcinogenic and transferable significantly to foods. Underlying mechanisms according to the dispersion of MOA on fibers and their volatility are poorly described. This study reports one of the first mechanistic descriptions based on microscopic chemical imaging down to the fibers' scale. The observations are used to propose a microscopic mass transfer model incorporating the properties of the fibrous network. Homogenized diffusivities are compared with experimental ones for validation.

Methods

Model blotting papers were impregnated with various aromatic surrogates dispersed in good and bad solvents of cellulose fibers to reproduce the typical contamination profiles met in recycled papers. The 3D fibrous network was reconstructed in microcomputed X-ray tomography. The dispersion of solutes was directly imaged on fibers by combining Raman spectral imaging and laser scanning confocal microscopy. Apparent diffusivities were experimentally measured with the help of a modified Roe method involving a stack of paper sheets, including two formulated sources.

Results

The main observations were translated into mechanisms and a mass transfer model. Three factors limit the transfer across the paper sheet: the fugacity of the considered surrogate on the fiber, surface diffusion, and the distance between fibers. Highly volatile substances can cross several layers before being re-adsorbed on fibers. Low volatile aromatic compounds that are highly precipitated travel much shorter distances. Impregnating fibers with such MOA by evaporating a poorly wetting solvent reduces their mass transfer dramatically. These effects were experimentally measurable with the Roe method and offered an easy path to validate our microscopic model. The proposed model combines a mutual diffusion model in the gas phase and an "evaporation-condensation" model for the interactions with the fibers. The model is homogenized by assuming a periodic elementary representative volume. Predicted diffusivities were shown to be in satisfactory agreement with experimental macroscopic values.

Conclusions

The effects of fiber packing were captured by the microscopic model. They enable the design of optimal density and tortuosity to grant sufficient barrier properties at the scale of food packaging.

Oral

Evaluation of corrosion resistant coatings in metal cans used for heat treated packaged foods

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This study investigated heat-induced changes to chemical compounds in tomatoes and chicken and examined how these compounds initiated morphological changes to corrosion resistant polymeric coatings laminated to the internal wall of metal food cans. Changes to the coating were measured using X-ray diffraction, Fourier transform near-infrared spectroscopy, and scanning electron microscopy. The elemental composition of the coatings in the cans before and after heat processing were investigated using energy-dispersive X-ray spectroscopy (EDS). As controls, some cans were not filled with the tomatoes and chicken, and some cans were filled with these foods then sealed, but not heat-treated. For the heat-treated tomato and chicken-filled cans, they were sealed, retorted (at 121 °C, 30 min), then stored at 49 °C for 50 days. Selected-ion flow-tube mass spectrometry was then used to measure the concentrations of volatile compounds (sorbed from the tomatoes and chicken) in the polymeric coatings of the unprocessed and processed cans. The results showed that thermal degradation of amino acids in the tomatoes and chicken gave rise to volatile methyl sulfides that were subsequently sorbed by the cans coatings. This process caused chemical modifications to the coatings, changes to their morphologies, moisture uptake by their polymeric structures, delamination, and exposure of the base-metal in the cans. These changes allowed electrolytes, gases and moisture in the tomatoes and chicken to initiate corrosion in the walls of the cans. As a result of the corrosion, tin and iron sulfide formed and migrated from the walls of the cans towards the tomatoes and chicken. The concentration of these metallic compounds in the coating and food items were quantified using induction coupled plasma and EDS. These results provide us with a better understanding of how tomatoes and chicken give rise to corrosion in metal cans.

Sustainability, food chain & decarbonisation

Oral

Impact of the process and the extraction method on lipids extraction from microalgae

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The agri-food industry has to face new challenges in response to current societal expectations: producing high quality food (nutritional, organoleptic, sanitary, etc.) while respecting the environment. In addition, it must introduce new sources of protein in order to feed the planet (9 billion people in 2050) and to reduce the quantity of animal proteins in products. Microalgae are promising bioresources with interesting nutritional potential. Indeed, these raw materials have protein contents of between 14 and 77% with high digestibility values and interesting amino acid profiles. They also have high lipid contents with a high proportion of polyunsaturated fatty acids (including ω3 and ω6). The development of sustainable transformation processes for this bioresource is a real challenge, in order to obtain different fractions (lipid and protein) with interesting properties for the transformation into finished products.
The aim of this work is to study the impact of the pre-treatment before the lipid extraction from Chlorella Vulgaris. Four processes were considered: atomisation, freeze-drying, atomisation coupled with grinding, freeze-drying coupled with grinding. Three lipid extraction methods were applied on each process material: i) by solvent (chloroform and methanol), ii) by Accelerated Solvent Extraction (dichloromethane and methanol), iii) by supercritical CO2. Impact of these processes and extraction methods on fraction obtained was characterized by measuring the extraction efficiency, the pigment and lipid content of the extractives and by identifying the fatty acids by gas chromatography.
Results show that the pre-treatments undergone by the biomass do not affect the extracted fatty acid profiles but do affect the yield. The best yields are obtained when the biomass is ground. Supercritical CO2 extraction has a lower yield than the other two extraction methods. However, it is extremely selective on the extracted compounds by allowing the extraction of 75% of the neutral lipids under the implemented conditions.

Sustainability, food chain & decarbonisation

Oral

Optimization of key growth parameters involved in biomass production of Pavlova gyrans and their effects on the fatty acid profile and the protein content

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Microalgae have been presented as an interesting source of bioactive compounds for human consumption in several industries, such as nutraceutical, pharmaceutical or cosmeceutical. Their rich composition in anti-inflammatory and antioxidant compounds (e.g., polyunsaturated fatty acids (PUFAs), proteins) have shown protective effects against several human diseases (e.g., cardiovascular, cancer). Despite their increasing popularity, current limitations related to microalgae production hinder their cost-effectiveness and their widespread application and consumption, falling short of the market demand. Among the main bottlenecks, it is possible to highlight the proper control of the growth conditions targeting the improvement of both biomass production and biochemical composition, according to the microalga species/commercial application.
This work aimed at maximizing the biomass production of the marine microalga *Pavlova gyrans*, commonly used in aquaculture for feed application due to its high content of n-3 fatty acids and phytosterols, through a two-step approach. Firstly, a Plackett-Burman design (PB) was used to identify the most significant abiotic factors ($p < 0.10$), among the seventeen tested. Then, a central composite rotatable design (CCRD) was applied to optimize the key parameters found in PB experiments, being the optimal formulation validated against the control conditions (Walne´s medium). The cultures resulting from the CCRD assays were further characterized regarding their content of protein and lipids, as well as the fatty acid profile.
The PB design identified light intensity, NaNO3 (both with positive effects), and CuSO4.5H2O (negative effect) as the critical parameters ($p < 0.10$) involved in the biomass productivity of *P. gyrans*. These variables, together with NaH2PO4.H2O – a biologically important nutrient with considerable significance ($p = 0.13$) - were optimized in the CCRD design, which determined 700 µmol.photons.m^{-2}.s^{-1} of light intensity, 1500 mg.L^{-1} NaNO3, 6 µg.L^{-1} CuSO4.5H2O, and 40 mg.L^{-1} NaH2PO4.H2O as the optimal conditions for enhanced maximum biomass production (*Xmax*). Compared to the Walne's medium, the optimal formulation allowed a 3.8-fold increase ($p < 0.05$) in *Xmax* (2.26 g ash free dry-weight.L^{-1}), along with improved biochemical composition (p=0.05), namely increased protein content (10.59-30.76 % DW), PUFAs content (37.13-47.11 %TFA), n-3 fatty acids (26.49-38.27 %TFA), DHA (5.73-10.33 %TFA), and EPA (17.09-20.69 %TFA – $p > 0.05$).

Sustainability, food chain & decarbonisation

Oral

Integrated process conception to produce a soluble protein extract from Tetraselmis chui with low color for food application

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Microalgae constitute an interesting source of proteins for the food industry thanks to a high protein content, a balanced amino acid content and a high surface productivity. It can be consumed raw but several aspects are hindering their consumption such as low digestibility as well as strong color induced by the chlorophyll and taste. These problems can be solved by a biorefinery process, usually consisting of a protein extraction followed by purification. The present work, part of the PROFUTURE European program, aimed at enhancing the protein recovery from Tetraselmis. The general process applied consists of cell disruption, with freeze-thawing or bead milling, centrifugation and purification with ultrafiltration or isoelectric precipitation.
A protein yield of 8% has been obtained after a simple thawing and centrifugation, with a low colored supernatant whereas a low soluble protein extract, with a green color, has been obtained by bead milling and centrifugation, with a mass yield of 12% of total proteins. The 4% gain with bead milling in comparison to thawing might not be sufficient to justify bead milling based on cost and environmental reasons. Hence, the supernatant from the thawed biomass has been concentrated and purified with two techniques: isoelectric precipitation (IEP), a conventional technique, and membrane filtration, being environmentally friendlier and softer. The isoelectric precipitation was not effective for the precipitation of Tetraselmis proteins. Membrane filtration, using 10 kDa membranes, was able to retain and purify supernatant proteins with a recovery yield up to 86% on this operation unit. A scale up has been applied on the final process, with the treatment of 10 kg of dry matter, and the purified proteins showed interesting foaming properties for a future valorization. However, there is still a need to deeply understand the physico-chemical interactions of the proteins, within the microalgae extracts and along the process, which limit the global yield and the industrial development.

Oral

Volcanic proteins: Galdieria sulphuraria protein profile and bioaccessibility

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Galdieria sulphuraria is considered one of the most promising microalgae for food applications. G. sulphuraria can uptake inorganic carbon CO_2 as well as more than 30 organic carbon sources. The extreme growing conditions such as low pH (as low as 0.2), high temperature (up to 57 °C) and osmotic pressure (2-3 M), can be used to create a selective environment that prevents the proliferation of unwanted microorganisms. G. sulphuraria is rich in proteins (65% w/w) and it might contain up to 10% w/w of the blue pigment phycocyanin.
Nevertheless, amino acid composition and overall protein fraction are not the only characteristics that make a protein source suitable for human consumption. Protein bioaccessibility can be defined as the quantity or fraction of a protein that is released from the food matrix in the gastrointestinal tract and becomes available for absorption and it is as important as the quantity of the protein fraction. In this study, we compared two strains of G. sulphuraria cultivated autotrophically and mixotrophically over a month in pilot-scale photobioreactors under nonsterile conditions. During mixotrophic cultivation, a constant supply of glucose was provided as the sole carbon source. An in vitro digestion model was used to measure protein bioaccessibility, following the harmonized protocol INFOGEST 2.0. The low pH (<1.9) used for cultivation successfully prevented microbial contamination. The two strains had similar autotrophic (13 $g \cdot m^{-2} \cdot day^{-1}$) and mixotrophic biomass productivities (30 $g \cdot m^{-2} \cdot day^{-1}$). Comparing the biomass composition of the two strains, G. sulphuraria SAG 108.79 and ACUF 064 had 51% and 64% (w/w) protein and 4% and 9% (w/w) C-phycocyanin content, respectively. Interestingly, G. sulphuraria SAG108.79 showed a protein bioaccessibility of 62% (w/w), in line with other microalgal species, whereas G. sulphuraria ACUF064 had a protein bioaccessibility of only 14% (w/w) No differences in the amino acid profile were found between the two strains or between trophic modes. The amino acid profile was well-balanced, rich in all the essential amino acids, especially methionine and cysteine, fulfilling FAO dietary requirements for adults. Stable and well-balanced protein profiles are encouraging results for future food applications of this species.

Oral

Effects of moderate electric fields on microalgae cell structure –novel perspectives towards improved bio accessibility of metabolites

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The use of microalgae in food industry has started to gain some interest due to their unique and promising characteristics. They are well known to present several compounds of interest such as proteins and essential amino acids with high nutritional impact for human and animal health. Usually, microalgae present a complex cellular structure, composes by strong polysaccharides, which affects their digestibility, and consequently the bio accessibility of their metabolites during gastrointestinal digestion. These could significantly decrease microalgae nutritional value. The electric fields processing have become an interesting approach in food industry as a way of inactivate some microorganisms which could be present in foods causing impact in the microorganisms cellular structure. Electro and thermal-permeabilization effects can result in a more fragile cell wall which in turn will increase bioaccessibility or leverage extraction of intracellular compounds of great interest given their nutritional value and functionality such as proteins. This work aims to establish a strong body of knowledge about how moderate electric fields (MEF) technology and its attendant ohmic heating effect can be combined to disrupt microalgae cell wall structure towards improved accessibility of intracellular compounds. Flow cytometry has shown that for example *Chlorella vulgaris* cell morphology - i.e., size and complexity – can change significantly after electroheating treatments, when variables such as electric field intensity (from 2 to 225 V/cm) and thermal load (temperature -treatment time binomial) are properly designed. Pulsed heating treatments, applied at 90 °C in less than 10 s, resulted in an accelerated extraction (within the first hour) of compounds, such as chlorophylls, from treated cells to an aqueous ethanolic solution. Interestingly, these treated cells of *Chlorella vulgaris* also presented a higher ability to naturally flocculate thus confirming cellular structural damage imposed by MEF. Results obtained under this study unveil that MEF pre-treatment in microalgae biomass has potential to bring novel insights towards bioaccessibility of important intracellular bioactive compounds during gastrointestinal digestion, as well as to contribute to a more efficient downstream processing regarding harvesting and extraction operations.

Sustainability, food chain & decarbonisation

Oral

Creating meat-like fibrous structures based on microalgal proteins with high moisture extrusion cooking

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Objective
Microalgae have high growth rates, can be cultivated in non-arable areas and are rich in proteins as well as micronutrients. In context of climate change, they are a promising non-animal protein source. However, the fabrication of consumer-accepted foods based on microalgae is challenging due to unfamiliar taste, texture and colour. Furthermore, our research illustrates that microalgae proteins have different characteristics compared to the plant proteins. This influences their structurability. Processes such as extrusion have to be adapted in order to structure microalgae proteins. Our research puts protein properties in context with processability.

Methods
Amino acids profiles, mineral compositions, protein size and solubility of soy protein concentrates (SPC), pea protein isolate and Auxenochlorella protothecoides biomasses (APB) have been examined and compared. A metric system to assess the ability of a raw material to build networks via hydrogen bonds, disulphide bridges, ionic bonds and hydrophobic interactions has been introduced. The effective propensity to texture was determined by extruding the characterised raw materials and subsequently analysing the extrudates with dynamic mechanical analysis.

Results & Conclusions
At fixed processing conditions, cutting force as well as double compression peak force decline by more than factor 3 for the 50:50 mixture of SPC and APB compared to pure SPC. The protein content of APB is with 47% lower than the protein content of SPC with 63%. However, even after adjusting the final protein content to a fixed value of 28% the peak force of dynamic mechanical analysis was still twice as high for pure SPC. This indicates that soy proteins have a stronger propensity to form fibrous structures. Our physicochemical analysis showed that all tested raw materials have comparable amounts of cysteine (0.01 mol/100g protein) and polar amino acids (0.23 mol/100g protein). However, the proteins of microalgae biomasses have fewer hydrophobic sidechains, are substantially smaller and have a higher water solubility. Thus, due to the reduced molecular size, more bonds are required to form a network of similar dimensions while the tendency to interact is lower because of high solubility. Increased processing time and higher temperature improved the texture of extrudates based on microalgal biomass.

Sustainability, food chain & decarbonisation

Oral

The Microbial and Physico-Chemical quality of Tenebrio molitor Powder: evaluation of the impact of four different manufacturing process

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Introduction: In Europe, entomophagy interest is growing to meet increasing demand for food diversity and protein supply. However, insect food safety concerns have been raised as it is a Nove food or in case of extensive human consumption. This study aims to evaluate the microbial quality and physio-chemical property of Tenebrio molitor (mealworm) powder, and to analyse the impact of four different process.

Methods: Four different processing pathways were carried out to obtain mealworm powders. Contents of dry matter, protein, fat, ash and water activity (Aw) have been determined on fresh and powdered insects. Microbiological analyses were undertaken at each step of processing trials to assess the contamination level and effects of different processing pathway. Predictive microbiology models were also used to evaluate the microbial inactivation effect of heat treatment steps on significant hazards.

Results: Fresh mealworm larvae contained 29.5g/100g of dry matter, including 66.1% of crude protein (19.5% of total), 19.9% of crude fat (5.9%) and 4.6% of ashes (1.4%) and a high Aw (0.986), similarly to conventional meat sources. Mealworm powders without oil extraction (A, C, D) contain significant amounts of protein (55.6-58.4%) and fat (23.6-28.2%). Fresh mealworm larvae showed a high level of microorganisms (mean total aerobic counts 8.4 log CFU/g), while significant hazards including *Salmonella* spp., *L. monocytogenes* and *C. sakazakii* were not detected and *E. coli, B. cereus*, *C. perfringens*, *S. aureus* were below the limit of quantification (<1.0 log CFU/g), except for sulfite-reducing anaerobes (1 log CFU/g) in analyzed samples. It was observed that heat treatments (boiling for 5 minutes or cooking at 80°C for 30 minutes) were sufficient to kill vegetative cells (2.8~5.1 log reduction) instead of bacterial endospores (0.3~1.8 log reduction). Predictive models also confirmed that most of the spores (especially *Bacillus cereus* group, *Clostridium botulinum* and *perfringens*) had the possibility to survive the applied heating.

Conclusion: Mealworm is a valuable source of nutrients compared to traditional meats. This study validated the efficacy of heat treatment step as a CCP of insect powder processing, providing primary data for the implementation of HACCP plans in the insect sector.

Sustainability, food chain & decarbonisation

Oral

Effects of vacuum microwave drying on drying characteristics and flavor of edible cricket

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Introduction: Edible insects are attracting attention as a new source of animal protein. However, in order to use edible insects as an alternative protein, their poor flavor must be improved. In addition, hot air drying, which is frequently used in the processing of edible insects, is concerned about low energy efficiency as well as poor quality of dried products. In this study, we applied vacuum microwave drying as a new drying method for edible insects and evaluated its effects on drying efficiency and quality.
Method: 10 g of house crickets (*Acheta domestica*) were dried using hot air drying, microwave drying, and vacuum microwave drying. Drying conditions were 70 °C, 600 W, 200 W and 30 hPa for hot air, microwave, and vacuum microwave drying, respectively, and crickets were dried until weight reached equilibrium. During each drying, crickets were weighed at regular intervals and moisture content was calculated. Dried crickets were powdered by using food mill. Then, GC-MS analysis was performed for aroma components.
Results and Discussion: The drying characteristic curves were obtained from the moisture content vs. drying rate plots. For all drying methods, the drying process occurred only in the falling-rate period. Therefore, we fit an exponential model to the measured values of each moisture content change. The results showed a high coefficient of determination of 0.99 or higher, indicating that this model was appropriate. The drying rate constants k were determined as 0.023, 0.337, and 0.235 h^{-1} for hot air, microwave, and vacuum microwave drying, respectively. In other words, the use of microwaves was shown to be useful in improving the drying efficiency of crickets. GC-MS analysis showed that significantly fewer aroma components were detected from the cricket powder dried by vacuum microwave drying than those by hot-air and microwave drying. Vacuum microwave drying allows drying under low oxygen conditions, which was thought to be related to the lower number of aroma components detected.

Oral

Effect of non-thermal assisted processing on the quality of house crickets: pulsed electric fields and electrohydrodynamic drying

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House crickets are an important source of nutritional compounds and a sustainable alternative to conventional livestock. Drying processes are applied to food materials to preserve their quality. Electrohydrodynamic drying (EHD) is a novel, non-thermal and energy conserving process, whereas pulsed electric fields (PEF) can accelerate the drying process and enhance the product quality. The applicability of PEF and EHD on house crickets was investigated. In a discontinuous treatment unit, fresh crickets were treated with PEF at 4.1 kV/cm with an electrode gap of 40 cm, 500 rectangular pulses and 25 µs pulse width. Afterwards, they were dried with a conventional oven dryer at 60 °C and with EHD at 8.6 kV with a mesh of metal wires as emitter and a distance of 40 mm between the emitter and the samples. Both drying processes were performed for PEF-treated and non-PEF-treated samples until the moisture ratio reached equilibrium. The drying process of all samples were modelled with various models (Newton, Page, Henderson & Pabis, Logarithmic, Wang & Singh and Midili), with the Page model being the most applicable ($\chi 2 < 0.001$ and $R2 > 0.99$). EHD was not able to reach a moisture equilibrium of the insects that was considered a dried state and was therefore used as an intermediate step to reduce oven-drying time. The dried samples were evaluated for their antioxidant capacity, progress of Maillard reaction, protein solubility, histamine levels, volatile profile and physical properties like color and bulk density. EHD decreased protein solubility by 26.3%, increased bulk density by 23.5%, increased the overall color change by 50% and reduced Maillard reaction products by 50.5%. PEF pretreatment increased the antioxidant activity by 23.8% and protein solubility by 53.2% for the oven-dried insects, while it reduced histamine levels by 14.5% for the EHD-dried insects. Finally, the energy consumption of the drying processes decreased by more than 50% by implementing EHD drying. Therefore, PEF pretreatment has been found applicable for enhancing the quality of dried house crickets, while EHD is suggested to be included in the drying process due to its lower energy consumption.

Sustainability, food chain & decarbonisation

Oral

Microfiltration as a mild alternative decontamination and fractionation method for lesser mealworms and house crickets

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Due to the global need for sustainably produced protein, novel protein sources like insects are currently being explored. In the insect industry, processes like blanching are currently used to inactivate micro-organisms. However, these methods denature proteins, limiting their use in industry. Mild alternative methods like pulsed electric field processing, high pressure processing, and microfiltration could be an alternative to blanching, but are not yet used in the growing insect industry. The aim of this study was to investigate whether dead-end microfiltration (0.2 µm polyethersulphone membrane) can be used on soluble fractions of lesser mealworm larvae (Alphitobius diaperinus) and adult house crickets (Acheta domesticus) at pH 3 and 8, to obtain functionally active, sterile fractions, without the use of blanching. The results showed that microfiltration was succesful in terms of microorganism removal, as no microorganisms (<100 cfu/mL) were detected in any of the permeates after microfiltration. The protein recovery of pH 3 fractions was higher than pH 8 fractions, and lesser mealworm fractions showed better protein recovery than house cricket fractions. Higher protein recoveries in pH 3 fractions could be explained by higher activities of endogenous proteases, thus obtaining smaller proteins that could easier pass the membrane. Permeates obtained at pH 3 showed significantly less enzymatic browning than pH 8 permeates, indicating that browning enzymes were inactive at pH 3. In terms of protein functionality, permeates showed a significantly improved foaming capacity compared to pre-filtrates. Fouling due to protein aggregation was the main factor limiting the membrane flux and thus the protein recovery. This caused more than half of the protein to be left behind in the retentate after one-step microfiltration. These retentates were found to be able to form heat-set gels for food applications. In conclusion, dead-end microfiltration (0.2 µm pore size) is a successfull and promising technique for the removal of micro-organisms from soluble fractions of lesser mealworms and house crickets. A pH of 3 is recommended during the extraction process, as it gave the highest protein recovery and can be used to combat browning.

Oral

Effect of the hexane defatting step on the protein profiles and techno-functionalities of pea and mealworm ingredients

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Recently, alternative proteins, mainly from pulses and edible insects, have gained popularity to support the global transition to more sustainable food systems. Nevertheless, sensory appeal and food neophobia represent major challenges which negatively affect the consumer acceptability. It was suggested that the integration of alternative proteins as ingredients (concentrate or isolate) in different food formulations could enhance consumer acceptability. Consequently, an increased knowledge of the effect of different processing methods on techno-functional properties of alternative protein ingredients is necessary. Multiple defatting and protein extraction methods have been explored to improve the protein recovery and purity. More specifically, efficient lipid removal from the solid food matrix remains conventional extraction by using hexane but its effect on novel proteins is still unknown. Consequently, this work aimed to evaluate the impact of the hexane defatting step on the protein profiles (2D SDS-PAGE, SEC-FPLC, surface hydrophobicity, ζ-potential) and techno-functionalities (solubility, foaming, gelling and emulsifying properties) of pea (*Pisum sativum*) and mealworm (*Tenebrio molitor*) protein fractions. As expected, we showed that hexane-defatted (HD) fractions had higher protein contents. Moreover, protein profiles were similar between the defatted and non-defatted (ND) ingredients. However, for mealworm, actin and hexamerin were only detected in the HD fractions. We hypothesized that these soluble proteins were imprisoned in adipocyte cells (fat body) and released during hexane defatting. Furthermore, HD fractions showed improved foaming properties for both ingredients. Indeed, the foaming capacity of HD mealworm proteins increased by 588% due to the alteration of protein intrinsic molecular properties during the defatting process. Interestingly, the foam stability of pea proteins was especially improved by the hexane defatting step. Indeed, HD fractions formed a visibly smaller and denser air bubble network compared to ND pea protein fractions, which allowed for better stability of HD pea foams over time. Our findings can be used to improve the foaming properties of alternative protein fractions to generate high-value-added ingredients for food formulation.

Sustainability, food chain & decarbonisation

Poster

Degreasing of the black soldier fly (Hermetia illucens L.) larve meal with supercritical CO2

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With the growth of the world population and the demand for food, edible insects are seen as an economic, nutritional and sustainable alternative. The black soldier fly (Hermetia illucens) has been highlighted for its nutritional composition, for its high content of proteins and lipids. Extraction with supercritical CO2 (scCO2), has been applied because it has many advantages, such as leaving no toxic residues in the flour and the extracted oil. In this research the pressure (P) and temperature (T) conditions in the extraction were studied, comparing the consumption, yield and solvent consumption in dynamic and intermittent processes. The extractions with scCO2 were performed at temperatures of 40, 45, 50, 55, 60 and 65°C and pressures of 20, 25 and 30 MPa. The best yields were obtained at pressures of 25 and 30 MPa at 60 °C and static time (St) of 30 min and 90 min continuous flow rate (20 mL/min) for all experiments. Intermittent process was performed at the optimized conditions (25 and 30 MPa at 60 °C) in 3 cycles. The first cycle (C), in which the flour and the solvent remained in contact for 30 min of static time (St), the pump was turned on and the outlet valve opened for oil collection until the determined CO2 mass was reached. After the collection, a new cycle was started with the same contact time and the same P and T. After the last cycle, the system was depressurized. The parameters analyzed were yield and CO2 consumption in each process. The dynamic and intermittent processes presented similar yields of 33.79 % representing the entire recovery of the oil present in the flour, which corresponds to 32.7 % of the oil contained in the flour, and did not differentiate between them. The intermittent process presented lower CO2 consumption, being half the volume of solvent spent in the dynamic. The intermittent extraction presented the same yield as the dynamic extraction. However, the extraction time and solvent consumption was considerably shorter. It is believed that this method of extraction in cycles (intermittent process) should be adopted, due to its important economic benefits.

Sustainability, food chain & decarbonisation

Oral

Mapping water demand and trends in food manufacturing

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The food industry, a major water consumer, is facing significant environmental challenges (i.e., depletion of freshwater resources due to climate change) that are building up pressure on food security – as the global population is growing, both food and water demand for food production are expected to increase too. In this context, this work identifies water consumption hot spots in food manufacture processes, which will help to allocate resources more effectively and create a more sustainable food chain.

Water usage data was collected from literature and clustered by product and processing technique. Before analysis, data was transformed into standard units when needed/possible.

Findings show that the meat and dairy sectors are the most water intensive ones – water is systematically used to rinse/clean surfaces, pipework and vessels and thus guarantee hygienic standards; however, most cleaning-in-place (CIP) protocols are based on very conservative and outdated protocols, which could be significantly optimised. Similarly, literature reveals scope for further improvement of sterilisation and pasteurisation operations used in packed foods (e.g., pouches, cans, jars) - alternative preservation techniques, like microwaves or pulsed-electric-field (PEF) are being slowly introduced in the sector, so heat could be generated without using water/steam. Water is also a main component in the formulation of a number of food products, although in most cases is removed either by evaporation or sublimation, through drying or freeze-drying processes. Therefore, processing of dough-based products, as well as processing of powder foods and ingredients, constitute a major source of water consumption, too. Finally, this study has analysed water usage per location too, revealing those areas/countries more compromised by climate changes and draught.

The outcomes of this work constitute valuable information for the sector and policy makers that can help to re-evaluate current environmental and manufacturing strategies, increasing sustainability and security of food chains.

Sustainability, food chain & decarbonisation

Oral

Development of eco-design tools for wastewater reuse or recycling in the food processing industries: the MINIMEAU ANR project – Application to a dairy case study

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In the context of strong and increasing pressure on water uses and punctual water shortage, the food industry currently faces challenges regarding water supply. Most food industry sectors are already engaged in water sparing by implementing good practices or common-sense actions.

The adoption of "good practices" generally results in a 15-20% reduction in water consumption. To go further, it is necessary to modify technological choices, but it is often difficult to find alternatives to water use. Thus, water recycling seems to be a necessary solution to water savings, and in particular the development of short recycling loops within the production line, before effluents mixing and any wastewater treatment plant. Given the complexity of industrial water networks, but also the strict requirements for food product quality and safety issues, implementing appropriate recycling or reuse processes requires well-adapted engineering tools to design and simulate them.
In this context, the French ANR MINIMEAU project (ANR-17-CE10-0015 MINIMEAU, 2018-2021, https://minimeau.fr) which associates academic partners (AgroParisTech/UMR SayFood ; INRAE/UMR ITAP), industry (ProSim), food institutes (CTCPA, ITERG, ACTALIA, IFV) and a transfer center (CRITT Agroalimentaire Sud), developed a method summarized as a flowchart, and several eco-design tools. Amongst the tools, one can find:
- a water pinch analysis to identify the major wastewater fluxes to be recycled or reused in order to optimize the water network;
- an inventory of the main pollutants or “key parameters” encountered, to be monitored or eliminated in the effluents (depending on the food sector);
- a new simulation module in a commercial software tool (ProSimPlus) to describe membrane processes, the reliability of which was validated thanks to experimental tests at a pilot scale;
- a water footprint and life cycle assessment (LCA) calculator to ensure that technical solutions implemented for reusing water flows do not result in pollution transfers that exceed the water savings benefits (due to needed energy and infrastructures).

Scenario propositions were tested in 10 companies with or without treatment (including membrane processes) and a case study on representative, although fictitious, data in the dairy industry showed up to 40 % of freshwater savings.

Sustainability, food chain & decarbonisation

Oral

Evaluation of Alternative-to-chlorination Disinfection Technologies in the Treatment of the Maltese Potable Water

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The Mediterranean Island of Malta is one of the most water-stressed countries in the EU and is challenged not only by water quantity concerns but also, by the deterioration of its groundwater quality. Reverse osmosis desalination of seawater provides 60-70% of the Maltese potable water content, with groundwater comprising the remaining percentage. Chlorination has been the adopted method of water disinfection prior to distribution. However, presence of chorine residuals and chlorination by-products in the distributed tap-water compromises its organoleptic properties and deters the public from consuming it. For the first time in the long history of the Maltese water resource management, project PURILMA (a collaborative project between the Water Services Corporation and the University of Malta) is attempting to optimise the content of disinfection by-products, minerals and natural organics in the treated blended water to generate a product that not only adheres to the EU drinking-water directive but also satisfies the sensory perception of the consumer. With the objective of minimizing the impact of chlorine residual on the quality of the distributed water we attempted assessing the potential of UV-C (254 nm), hydrodynamic cavitation, chlorine dioxide and in-situ chlorination as cost- and energy-effective decontamination alternatives to standard chlorination. All the tested technologies, but hydrodynamic cavitation, achieved a minimum 3 Log10 inactivation of the microbial load, with in situ chlorination and chlorine dioxide appearing more effective in the treatment of reverse osmosis and borehole water, respectively. For feasibility studies, the performance of the technologies was further evaluated on the following areas: a) implementation, b) practicality, c) adaptability, d) integration, e) environment & sustainability, and e) cost & effect. In situ chlorination, emerged as the most promising technology for implementation in pilot study work, followed by UVC and chlorine dioxide.

Sustainability, food chain & decarbonisation

Oral

Development of Acrylated Bioresin from Soybean Oil using Green Solvents

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Soybean oil epoxidation is approached through chemical, enzymatic and chemoenzymatic route. The major challenge in chemical method is use of high amount of acids. Similarly in enzymatic method, there is a significant substrate inhibition which makes the process very slow, inefficient and expensive. To overcome this, Deep Eutectic Solvent (DES) were used in the epoxidation process. In total, 28 DESs were screened and potential DESs were identified for soybean oil epoxidation followed by optimization of the reaction condition. Use of DES resulted in reduction the use of acid significantly i.e. up to 50%, while ensuring for 83% yield of epoxy product. Acetylcholine chloride (AChCl): Oxalic acid, Choline Chloride: Butyric acid and Acetylcholine Chloride: butyric acid based DES was found promising in catalyzing soybean oil epoxidation with a yield value of more than 80%. This was also confirmed by FTIR spectroscopy, as evaluated by intensity at wave number 825 and 3008 cm-1. This makes the process of epoxy resin development as greener and economic as compared to convention chemical or enzymatic method. Subsequently, acrylated epoxidized soybean oil based bioresin was developed following curing with acrylic acid. Differential Scanning Calorimetric study was performed to understand the thermal stability rheological properties were evaluated to assess the processability of the developed bioresin.

Sustainability, food chain & decarbonisation

Oral

Refining of plant proteins from food processing side streams using Natural Deep Eutectic Solvents

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Objective
The objective of this study was to extract off-taste and off-flavor components of plant proteins using a novel class of food grade solvents, Natural Deep Eutectic Solvents (NADES) instead of standard aqueous extraction for plant protein refining. This study was conducted to identify processing windows for protein refining from food processing side streams, pea protein concentrate (PPC) and rapeseed press cake (RPC).

Methods
NADES consist of food grade chemicals, a ternary amine (e.g., choline chloride, betaine, betaine chloride) as hydrogen bond acceptor (HBA) and a polyol (e.g., 1,2-propanediol, glycerin, urea, DL-lactic acid, and ethanol) as hydrogen bond donor (HBD). In this study, processing windows were defined based on a minimal solubilization of protein and maximization of the solubility of polyphenols using a custom factorial design approach. In addition, physico-chemical properties which are most relevant for the extraction efficiency (viscosity, water activity, pH, density, refractive index, surface tension, dielectric properties) of selected NADES were determined. A Folin Ciocâlteu test kit was used to determine the amount of extracted total polyphenols and a BCA assay was used to determine soluble protein.

Results
The stoichiometric HBA:HDB ratio of and the water content significantly ($p < 0.05$) affected all NADES physicochemical properties regardless of NADES temperature. In turn, NADES physico-chemical properties significantly ($p < 0.05$) affected the extraction efficiency of polyphenols and phytochemicals from PPC and RPC. The custom factorial design revealed that optimal solubilization of phytochemicals while minimizing the solubilization of proteins was achieved at low water content of NADES in the range of 5-10%. A correlation of NADES composition and physico-chemical properties and the results for the solubilization of proteins and polyphenols in NADES could be established.

Conclusions
This study explored the differential solubility of proteins and phytochemicals in NADES. Further aqueous extraction of proteins and recycling of NADES after NADES refining needs to be explored. A circular process needs to be established to use this ‘green chemistry’ approach to yield functional, plain tasting, and colorless plant protein that can be applied in a broad range of foods and a substitute for animal protein.

Sustainability, food chain & decarbonisation

Oral

Sustainable food processing requires dry fractionation and more efficient drying

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Energy and food prices are soaring due to the war in Ukraine. Climate changes accelerate and lead to periods of draught and flooding dramatically affecting the harvest of crops. Food security for large part of the global population is at stake. We need to intensify our efforts to come up with creative solutions to feed the world. In this contribution I will discuss that traditional wet processing technologies for making food ingredients consume enormous amounts of water and energy and that these can be replaced by making use of dry fractionation. For many biological materials the combination of milling and dry separation such as air classification or electrostatic separation can be used to prepare enriched ingredient fractions with interesting functional properties. We study the properties and disclosure of biomass and use this insight to design combinations of milling and dry separation techniques such as air classification and electrostatic separation to effectively make ingredient fractions that are enriched. We discovered that the protein-enriched fractions obtained have high fibre and micronutrient levels and retained native functionality, which is interesting for many food applications and fits into a healthy diet. However, drawback of dry fractionation is that purity is limited. In that case a hybrid approach is suggested in which part of the ingredients are further processed by wet processing. Wet processes usually require a spray drying step to obtain shelf-life stable and functional ingredients. We calculated that by optimizing spray drying operations in terms of energy consumption and material losses, we can save about 38-76% of the amount of energy spent during drying. Therefore, we deepen our understanding on behavior of concentrated biological materials to make this process extremely more efficient. We do this by mimicking the spray drying process at the smallest relevant scale, i.e. the single droplet and combine that with modelling and pilot-scale testing. Next to these efforts, we recently started a large project on the use of electric driving forces to accelerate dewatering and drying during food production. With this, we ultimately aim at processing of our foods with minimal energy input while fueled by renewable energy.

Sustainability, food chain & decarbonisation

Oral

Developing methods and tools for the agri-food sector for sound environmental assessments based on a life cycle and multi-criteria approach in the view of eco-design and environmental labelling

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The current food system is facing many societal challenges, which are leading food companies to reconsider their practices throughout the value chain, in order to be part of the required food transition, in synergy with ecologic and energetic transitions and aligned with new consumer expectations regarding sustainability. Challenges are numerous: optimising the use of resources, preserving the biodiversity, strengthening food sovereignty, etc. To enable targeted action on the issues at stake, reliable diagnostic tools are a prerequisite. Life Cycle Assessment (LCA) is used to evaluate the environmental impacts of the production, use and end-of-life of products, and to evaluate the potential gains from an ecodesign approach. The environmental assessment can be carried out at different scales (unit operation, product, company, sector). Sectoral guidelines and calculation tools are being developed by actors across the whole value chain to enable the economic players in the sectors to be increasingly autonomous in their products evaluation and ecodesign approaches. These initiatives will be further encouraged by the development of the environmental labelling of food products planned by the French government and studied at the European level. Important issues remain concerning the method, i.e. the calculation algorithm and the rationale behind, and the level of precision of the data to be mobilised. The French technical institutes from the agri-food sector are strongly involved in the work carried out in collaboration with ADEME and INRAE to provide reference environmental impact values for raw materials, transformation processes and packaging elements, while consolidating methodologies and environmental indicators. Current projects include contribution to the continuous improvement of the public Agribalyse database and the development of sectoral calculations tools for instance for oil, meat and milk products. This work feeds into the required developments to make the LCA framework operational both for environmental labelling and for eco-design approaches that can be undertaken at sector level or company level. The aim is to promote life cycle thinking as a decision-support tool to improve the food system sustainability.

Sustainability, food chain & decarbonisation

Oral

Systematic review on distributed food cold chain systems for resilience and sustainability

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The global economy was already struggling to recover from COVID-19 and the rising living costs before the Ukraine war further deepened the food crisis. The shocks show the urgent need for more localised food supply to ensure food is always accessible for everyone at an affordable price. Furthermore, the need for sustainable cold chains is becoming increasingly important to improve food security, decrease the global emission in food systems and reduce food waste and loss. Food cold chains need to be energy efficient and climate friendly. This paper presents a systematic literature review on decentralised food systems and food cold chains to explore the extent to which resilience and sustainability have been considered in research. We identify, key themes that emerge, the gaps in research, and show the need for considering decentralised food cold chain systems that can enhance resilience and reduce GHG emissions.
The literature search was split into three parts: systematic literature search of decentralised food systems (DFS), systematic literature search of food cold chains (FCC) and the authors' personal search on DFS and FCC. The systematic literature search shows very limited publications on DFS (8), whereas a considerable number of publications could be found on FCC (82). The decentralised food system publications' focus was to compare decentralised and centralised food manufacture of specific food types (e.g. ice cream, cereal and porridge). These research highlight that the cost of switching from centralised to decentralised food manufacture is highly dependent on the type of food. For example, decentralised porridge manufacture is more profitable than centralised manufacture; however, this does not apply to bread production due to lower profit margin per unit for bread. In contrast, the FCC publications concentrate more on the storage and transport stages of the food supply chain due to them being the more energy intensive part of the cold chain. There is need for a comprehensive study of energy, environment, social and economic cost and benefit of localised food cold chain systems for resilience and sustainability

Oral

Comparative environmental evaluation in bakery and brewing sectors with the use of BSG and unsold bread in a circular economy context

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Keywords: Processing, System,

This study assessed the environmental impact of beer and bread production in the context of a circular economy using the LCA approach. It consists in evaluating innovative products like brewery spent grain breads and beers made by unsold bread. The supply chain considers, for both systems, the cultivation phase, milling, malting and production of ingredients (salt, yeast and hops). One of the most important hot spot for both productions is cultivation. In bread production, the hot spots are also bakery and proofing steps. In brewery process packaging step is the biggest contributor by far followed by boiling and hopping. In addition, along BSG and unsold bread stabilisation process the hot spots are drying and co-product transportation. Non-innovative products have the highest impact. In the majority of organic cases land use and marine eutrophication are significantly reduced after the use of co-products. The results support innovative products. In fact, it helps to give a general idea of which product is better from an environmental point of view and if it is significant. The last step was to compare innovative and circular system with a non-innovative one. The innovative one underlines few environmental impact categories with significant less values like Freshwater Ecotoxicity, Land Use, Marine Eutrophication, Mineral Resource Scarcity, Stratospheric Ozone Depletion and Terrestrial Acidification; Fine Particulate Matter Formation; Global Warming; Ozone formation, Human Health; Ozone formation, Terrestrial ecosystems and Terrestrial Eutrophication. In conclusion, positive results about circular economy are find. However, further studies are needed in order to obtain more primary data and less assumptions.

Sustainability, food chain & decarbonisation

Oral

Environmental performances of the production of dried lactic acid bacteria concentrates protected by fructo-oligosaccharides

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Objective

H2020 PREMIUM project aims at eco-designing new strategies for preserving lactic acid bacteria concentrates using oligosaccharides, taking into account protective ability, process conditions and environmental impact. The first part of the project led to selecting three fructo-oligosaccharides as promising protective agents, and two processes (freeze-drying and spray-drying) as stabilization alternatives. The objective of this work was to compare these different options from an environmental point of view.

Methods

The environmental performance of six production scenarios has been assessed by Life Cycle Assessment, for two bacteria (L. bulgaricus and L. plantarum). Pilot experimentations were performed in duplicate, including all production steps of stabilized lactic acid bacteria: growth medium preparation, cell culture by fermentation, cell harvesting and concentration, protection, stabilization and storage at 4 °C, 25 °C and 37 °C. The biological activity of bacteria concentrates was assessed by the measurement of culturability and acidifying activity. The mass and energy flows during the process were collected either by sensors or manual measurement. The mainly used background database was Ecoinvent 3.6, completed by Agribalyse 3.0 for ingredients of growth medium. Impact characterization was performed using SimaPro 9.1.0.11 software and the EF3.0 method. Environmental indicators were weighted by the biological activity of the bacteria to take into account jointly environment and bacteria quality.

Results

The spray drying process resulted in more degradation of the bacteria activity than freeze-drying. However, depending on the storage temperature considered, it can be considered as an interesting alternative process from an environmental point of view. Even if the effect was not decisive, the choice of oligosaccharide could help to reduce environmental impacts by 10-20%.

Conclusion

Considering the large set of data generated, an in-depth analysis is underway to validate these preliminary trends. The stabilization process used as well as the choice of the protective molecules changed the environmental impact of the lactic acid bacteria production system. This study will provide valuable information concerning the identification of environmental hotspots of the manufacturing of dehydrated lactic acid bacteria concentrates.

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Sustainability, food chain & decarbonisation

Oral

From a universal sugar replacement strategy towards valorising untapped sources of fibre-rich sugar replacers from side-streams

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Recently, we have formulated a universal sugar replacement strategy based on physical chemical principles [1]. The strategy is centred on the hypothesis that two physical characteristics, the volumetric hydrogen bond density and volume-averaged affinity for water, has to be mimicked to obtain similar texture in sugar replaced foods. This strategy has been validated for biscuits [1] and cakes [2], using measurements of both physical and sensorial attributes. For potential sugar replacers like polyols or dietary fibers the two physical characteristics number are straightforwardly determined from values of the glass transition of the dry ingredients (or via viscosity), and the moisture sorption isotherm.

Via the physical principles underlying the sugar replacement strategy one can easily reason that hydrolysis product of cell wall materials can be healthy and sustainable alternatives to commercially available solutions like polyols and inulins. Sustainable sources of cell wall materials are readily available via side-streams from plant-based food (ingredient) processing. Hence, the physical principles underlying the sugar replacement strategy could be used to derive functional ingredients from cell wall rich side-streams by applying physical and enzymatic treatments.

In this contribution, we first discuss the physical-chemical principles behind the sugar replacement strategy, and its validation for biscuits and cakes by demonstrating the relations with rheology, phase transitions, structure and sensory. Subsequently, we show the extension of these physical-chemical principles to cell wall materials such as arabinoxylans and xylo-oligosaccharides. Relatively simple measuring techniques are used to demonstrate the applicability of the principles to these cell wall derived materials, which can allow for 1) fast screening of potential cell wall based ingredients, and 2) process control to optimize treatment conditions. Overall, the approach here presented shows potential for valorising untapped source of fibres as highly functional sugar alternatives.

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Oral

Cascade strategies for the full valorization of ley grass towards edible protein extraction and biofuel production

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Abstract

Ley (different species of grass and leguminous plants), is widely grown on the arable land of many north & central European countries. Although ley is important for crop rotation and landscape diversity, it is an underutilized resource which is still a promising raw material for food, feed and energy production. In this project, based on a zero-waste circular economy concept we studied an agricultural biorefinery system using ley by combining extraction of high-value components such as proteins with biofuel production. In the first step ley was fractionated into liquid and solid streams. The liquid stream went for protein extraction, the solid fraction was directed for ethanol and biooil production and the remaining organic matter was tested for biogas production.
Fresh and ensiled timothy ley after screw pressing were characterized, and valuable components for food applications were identified. Methods to increase yield and quality of the protein concentrate were also evaluated. The crude protein yield in the liquid fraction found to be higher for ensiled timothy compared to fresh but showed lower levels of true protein due to polypeptide chain degradation into smaller peptides and free amino acids during the ensiling process. The amino acid composition of both ensiled and fresh timothy was similar to that of soya beans. Protein precipitation of the liquid fraction from fresh ley using heat coagulation and isoelectric precipitation resulted in similar protein content in the concentrate. Enzymatic treatments combined with pressing increased the protein yield of the process.
The solid fraction after screw pressing was tested for ethanol and/or biooil production through HTL, hydrothermal liquefaction. The process found to be stable and the bio-oil produced was of high quality with high energy value and low ash content.
The potential to utilize the organic matter remaining in the residual water fractions after protein extraction (brown juice) and biooil production was tested for methane production in lab tests. The biogas production from the brown juice was fast showing that the remaining carbon was easily available.

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Sustainability, food chain & decarbonisation

Oral

Application of disruptive technologies for biorefinery of seaweeds for value chains

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Seaweeds has been explored for a range of high value ingredients however key sustainability challenges include valorisation of processing waste streams & develop energy efficient processing and extraction techniques. The objective was to set up a novel integrated biorefinery model of seaweed production with the valorisation of this biomass to high-value products. This study investigated and developed an energy efficient zero-waste production system for creation of value chains from sustainably produced aquaculture seaweeds. Application of disruptive technologies i.e. use of energy efficient drying system (e.g. Microwave drying), application of cavitation technologies (e.g. ultrasound and hydrodynamic cavitation) for bio-transformation and membrane technologies for fractionation of high value ingredients. This study developed 4 value chains i.e. soluble fibres (laminarin), biopolymer (alginates), bioactives (phenolics and amino acids) and proteins. The study demonstrates the application of innovative approaches to valorise side streams and processing waste for creation of eco-friendly zero waste value chains; optimize and implement innovative processing approaches across the value chain to obtain ingredients, biopolymers and bioactives. Extracted bioactives and high value ingredients demonstrated comparable properties with those extracted using conventional techniques. Life cycle impact assessment of complete seaweed value chain was developed to identify the energy demand and key environmental hotspots. Drying step in the processing chain was the most energy intensive process for the creation of value chains. This study demonstrates that the overall biorefinery process can be used by industries to improve their processes and develop zero-waste strategy for renewable biomasses.

Oral

Integrated design of a sustainable mobile fruit & vegetable processing unit

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The design of batch food processing plants is a complex problem where choices must be made at different scales (roughly product, process, plant) and according to different objectives and constraints. Multi-objective optimization (MOO) methods represent a relevant way to solve such problem, however it seems that in the food sector, it has not yet been used to its full potential (Madoumier, 2019).

In this case study, a mobile fruit & vegetable mobile processing unit aimed at reducing post-harvest losses in the context of sub-Saharan Africa was developed. This mobile unit is required to produce 4 products from thermally stabilized fruit and vegetables. In order for the mobile unit to be sustainable in this highly-constrained context, its efficiency is assessed according to 14 performance indicators, and the different design solutions are simulated with a multi-scale model and analyzed.

To develop the model and perform the optimization of the mobile plant, a design methodology called "Methodology for the Integrated, Multi-scale and Multi-Objective Design of Systems" (MIMMODS) was followed. This methodology consists of six successive tasks leading to the construction of a decision support tool. The tasks constitute a guide to ensure that the decision support tool is able to (i) simulate the behavior of the processing unit at different scales and estimate its performance, (ii) take into account user preferences in the implementation context, and (iii) search for the design solution(s) that best satisfy the design objectives and the preferences, according to the principles of MOO.

An optimization algorithm was used to find a design solution that met most of the constraints. The decision support tool helped better understand the design problem, and a prototype was built based on the design solution, which confirmed the relevance of the chosen solution.

Sustainability, food chain & decarbonisation

Oral

Sustainable biotechnological approach to produce chitooligosaccharides from marine biomass: from biotechnological concept to downstreaming

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Every year, the processing of crustaceous generates more than 20 tons of highly perishable by-products that represent up to 45% of shellfish weight, including heads, thorax, claws, and shells. Marine by-products contain proteins and lipids of high value, with recognized biological properties. However, chitin and proteins in the shells are underexplored. Once extracted from proteins and minerals present in the shells, during two processes called demineralisation and deproteinisation, chitin can be chemically converted into chitosan (deacetylation), which in turn can be depolymerized into fragments of lower molecular weight, called chitooligosaccharides (COS). COS are a group of molecules with many applications in food, pharmaceutical and medical industries. Although common, the chemical production of COS is polluting and do not allow to control the structure of fragments, essential for the expression of COS's biological properties. We propose an innovative biotechnological approach to produce COS from marine waste using strains of microorganisms capable of generating enzymes can directly degrade chitin. We present all the strategies and challenges involving the creation and validation of a bioprocess for this purpose, from the choice of microorganism and biotechnological concept to the establishment of the bioprocess. The first step is the characterisation of the marine waste, because the properties of chitin (crystallinity and molecular configuration) change between species and influence subsequent processing. Then, microorganism selection is done, according to the referring processing step needed to transform the marine residue into COS: demineralisation, deproteinisation, deacetylation and depolymerisation. A screening of microorganisms is done for each one of these four steps, aiming maximum enzyme production and production yield. Each unit operation can either be done (a) by direct fermentation or (b) the enzyme is produced, purified, and then applied to the marine biomass. Finally, the material will be separated and purified using membrane separation technology to produce COS and protein-enriched fractions. The proposed biotechnological approach can produce COS from a high pollutant waste, with the quality required to express COS health-promoting properties and proposing the recovery of residual proteins that can reduce the cost of production and decrease the environmental impact of the marine industry.

Oral

Sequential batches strategy for the enhancement of protein recovery from salmon frames by proteolysis

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The aim was to test a new operational strategy consisting in sequential batches where the aqueous phase containing the soluble peptides is withdrawn and the remaining solid phase is submitted to a second batch. The hypothesis is sustained in the fact that peptides inhibitis the protease action, thus, the protein extraction should increase when they are withdrawn.
The strategy was tested for the hydrolysis of salmon frame proteins by 13 AU subtilisin per kg at 55°C and pH 6.5 (native) during 2 h in a regular batch. Two sequential batches were operated during 1 h each at the same conditions. After 1 h the reaction mixture was centrifugued and the different phases weighted and analyzed for nitrogen content. The solid phase was hydrolyzed in a second batch during 1 h at the same operating conditions.
The nitrogen extraction was 26.6% ± 0.6 after 2 h of hydrolysis in a regular batch operation. Two sequential batches were operated during 1 h each with the same total protease dose (13 AU/kg) distributed as 75/25, 50/50 and 25/75 percentage in the first/second batch. The nitrogen extraction resulted in 42.9% ± 3.9, 45.9% ± 1.7 and 48.7% ± 0.1 for each protease dose distribution, respectively. These results showed that an increase in nitrogen extraction can be achieved without increasing operation time and protease dose. The sequential batches were also tested without the addition of protease in the second batch. The nitrogen extraction was 43.4% ± 1.5, 43.4% ± 3.3 and 35.3% ± 0.3 for protease dose of 75%, 50% and 25%, added to the first batch and without addition in the second batch, respectively. The adsorption of subtilisin was inferred from results as an explanation for the hydrolysis reaction observed in the second batch.
The nitrogen extraction was significantly increased with the sequential batches strategy without increasing the operating time and protease dose compared to a one batch operation. A higher nitrogen extraction was obtained even without addition of protease in the second batch. The sequential batches is a promising strategy to enhance the efficiency of the enzymatic hydrolysis of byproduct proteins.

Sustainability, food chain & decarbonisation

Oral

Pilot-Scale Protein Recovery from Cold-Pressed Rapeseed Press Cake

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The agricultural sector is responsible for about 30% of greenhouse gas emissions, and thus there is a need to develop new plant-based proteins with lower climate impact. Rapeseed press cake, a by-product from rapeseed oil production contains 30% high-quality protein. The purpose of this study was to upscale the recovery of rapeseed protein from cold-pressed rapeseed press cake to pilot scale and investigate the effect of recirculation of the spent solids fraction on protein recovery yield. Proteins were extracted from cold-pressed rapeseed press cake under alkaline conditions (pH 10.5) followed by precipitation with citric acid at pH 3.5. Separations were conducted in pilot scale with a continuous decanter at 20 L/h. The recirculation of the spent solids fraction was repeated three times and protein yields, proximate composition, amino acid profile, glucosinolate content, and phytate content were analyzed in the corresponding protein concentrates. The experiments showed that it was possible to increase the recovery of rapeseed protein on a pilot scale by recirculation of the spent solids fraction. Recirculating the spent solids fraction once increased the accumulated protein yield from 70% to 83%. The ef?ciency of the extraction process was signi?cantly higher in the ?rst and second cycles compared to the third and fourth cycles, where only an additional 2% was extracted. The amino acid composition showed high levels of essential amino acids and was not reduced throughout the recovery process. The glucosinolate content was successfully reduced in the protein concentrates after one cycle and was in the same range as commercial plant-based protein ingredients. The phytate content was reduced in the protein concentrate after one cycle, though additional process steps are needed to further reduce the phytate content and limit the negative effect on mineral uptake. It was possible to increase the protein recovery yield by the recirculation approach and the amino acid profile was not deteriorated. This opens possibilities to upscale a protein recovery process with a higher economic efficiency.

Sustainability, food chain & decarbonisation

Oral

Process development for the valorization of the residual stream of sunflower oil press cake

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Sunflower oil press cake is a plant protein rich matrix that is usually utilized as animal feed. Since this residual stream is exceedingly high in value, it is desirable to make it available for direct human use on a larger scale. For this purpose, sustainable processes characterized by minimal use of environmental resources should be employed. Therefore, the suitability of solid state fermentation and membrane filtration for functional improvement, extraction, and purification of the plant proteins was investigated. The extracted proteins could be used as valuable ingredients in food and natural body care products.
Protein modification was carried out by solid state fermentation using *Aspergillus niger* as the microorganism. Concentration and fractionation of the proteins was realized by diafiltration using membrane microfiltration and nanofiltration.
The product composition was analyzed in all process steps regarding its nutrient components and selected phytochemicals and toxins. The growing microorganisms of the solid state fermentations were cultured on agar plates to check the progress of the fermentation and to detect contaminating microorganisms. The distribution of the molecular weight of the proteins was determined by gel electrophoresis after the different process steps. Chemical and physical analyses of the product were performed to determine various functional properties. These include foam formation, foam stability, solubility, water binding capacity, emulsification behavior and gel formation.
The results show that protein size distribution and functional properties can be modified by solid state fermentation with *Aspergillus niger*. Furthermore, fermentation of sunflower oil press cake is possible without being disturbed by other microorganisms. Membrane filtration processes were successfully applied to fractionate and purify proteins. In addition, polyphenol content in the final product was reduced. This is crucial for a neutral color in subsequent further processing in food and natural personal care products. From these results, it can be concluded that protein quality and molecular size distribution can be selectively adjusted by the process parameters of solid state fermentation and microfiltration. The combination of these processes therefore exhibits a promising sustainable possibility to produce valuable plant proteins for the usage in food and natural personal care.

Sustainability, food chain & decarbonisation

Oral

INFLUENCE OF MECHANICAL AND ENZYMATIC TREATMENTS ON THE MICRONIZATION AND FUNCTIONAL PROPERTIES OF HAZELNUT SKINS

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Nowadays, in the European Union the agri-food sector generates around 88 million tonnes of waste per year causing and high environmental impact and resulting in the loss of valuable nutrients and bioactive compounds. Hazelnut (*C. avellana* L.) is a feedstock used in the food industry, especially in the confectionary. sector. About the 90% of the hazelnuts are used as shelled and roasted and the main waste derived from the roasting process is represented by skin which account for 2.0 % of the entire fruit. Recently, studies on the composition of hazelnut skin suggest their application as functional food ingredients due to its richness in polyphenols and dietary fiber. However, the main applications consist in the use of hazelnut skin extracts. This study aims to transform whole hazelnut skin in a byproduct with improved physicochemical and functional properties to be used as a bioactive supplement in food by using mechanical micronization associated with enzymatic hydrolysis.
High-shear homogenization was performed by using Colloidal mill by set the lowest gap between the rotor and stator and keeping the temperature at 50°C for different time (5, 10, and 20 min). Xylanase and alkaline-cellulase were added separately and in sequential combination during the milling treatments. Finally, the particle size, swelling index, water and oil retention capacity of the treated hazelnut skin were detected.
The results shows that the lowest particle size (D_{50}: 67.2 µm and D_{90}: 180 µm) was obtained after 20 min of milling. Moreover, the enzyme-assisted micronization via sequential addition (10 min xylanase - 10 min alkaline cellulase) represent the best condition to significantly reduce the particle size (D_{50}: 45.3 µm and D_{90}: 104 µm). This is because the enzymatic degradation of superficial fiber of microparticles reduce the hydrodynamic diameter and modify the structural and functional attributes of the hazelnut skin particles increasing the swelling index and their water and oil retention capacity.
In conclusion the enzyme-assisted micronization can be considered a new approach to recovery hazelnut skin to be incorporated directly into food formulations as a vehicle of bioactive compounds and/or as food stabilizer.

Oral

Valorisation of pomelo (Citrus maxima) peels and corn (Zea mays) cobs to be innovative gelators for oleogels, hydrogels and bigels

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Valorising plant by-products is a feasible approach to reduce environmental risks and improve their values. Many plant by-products are fibre-rich and amphiphilic that can be utilised as health-promoting functional ingredients. This study presents a valorisation of pomelo (Citrus maxima) peels and corn (Zea mays) cobs into powder form with various particle sizes (125, 250 and 500 µm). They were mixed with either rice bran oil or water (60 – 90% w/w each) at room temperature for 2 mins to produce oleogels (OG) and hydrogels (HG), respectively. This suggests that the gelation process using the pomelo peel (PP) and corn cobs (CC) powders (10 - 40% w/w) was robust compared to other conventional gelators, which typically required excessive heating time and temperature. Analyses of the chemical composition indicated that fibres are abundant in both powders, providing structural entities for the gelation. Examination of the gelators' antioxidant profiles showed that PP had a higher antioxidant capacity than CC, implying PP gels can have a longer shelf-life than CC gels. The PP and CC powder particle size and concentration significantly impacted texture, rheology, microstructure and water/oil loss. Both HGs and OGs could not be formed with 500 µm particles. Stable HG & OG gels were produced with the smaller sizes (125 and 250 µm) of PP powder (10 – 35% w/w) and CC powder (20 – 40% w/w). Increased particle size and gelator concentration promoted hard and brittle gels and vice versa. However, large particle sizes and high gelator concentration decreased the oil/water loss. The microscopic images showed that the gelation was due to the interaction between gelator particles and the solvent droplets, and smaller particles promoted more uniform structures. Based on these results, bigels were developed from 125 µm PP powder. Preparation of PP bigels included mixing preformed HG and OG at various ratios, and adding PP powder (15-25%) into water-in-oil emulsions. The bigels formed from the set HGs/OGs appeared to be more stable, harder and elastic than those produced from the water-in-oil emulsion template. The developed OG, HG and bigels can find applications in formulating low-fat products and encapsulation of bioactives.

Sustainability, food chain & decarbonisation

Oral

Mycoprotein as novel functional ingredient: mapping of functionality, composition and structure throughout the Quorn fermentation process

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The production of mycoprotein by Quorn Foods for use in their meat-replacer products offers a potential sustainable alternative to functional ingredients of animal origin. We previously showed that an extract from the Quorn fermentation co-product (centrate) displayed high foaming, emulsifying and rheological properties.

This current study characterised the functional profile of mycoprotein material throughout the whole fermentation process in relation to changes in its composition and structure at different processing steps. The different fermentation streams and their centrifugation deposits and supernatants were investigated: broth, RNA-reduced broth (following a heat-shock RNA-reduction process) and centrate (following a second heating step and centrifugation).

The broth, RNA-broth and their deposits showed high viscosities while their hydrogels displayed high viscoelasticities in comparison with a whey protein concentrate (WPC) control. The RNA-broth and centrate supernatants showed higher foaming ability and stability than WPC. Oil-in-water emulsions prepared with the broth or its supernatant displayed similar emulsifying activity, emulsifying stability and oil droplet size distribution to WPC.

Large hyphal structures were observed in the broth, RNA-broth and their deposits, which contributed to their high rheological properties, while small fungal fragments contributed to oil droplet stabilisation in emulsions prepared with these samples. A cerato-platanin was found in higher concentrations in the RNA-broth supernatant and centrate as a result of cell damage following the two heating steps and possibly contributed to their higher foaming properties. Proteomic and metabolomic analyses showed evidence of upregulation of the mRNA decay pathway following the two heating steps. As a result guanine and guanosine derivatives were reported in higher concentrations in RNA-broth and centrate samples and possibly contributed to their foaming, emulsifying and rheological properties.

This study highlighted the potential of mycoprotein material from different Quorn fermentation streams as novel functional ingredient and the possibility to modulate its structure and functional properties by heating.

Oral

A new process simulator to optimize production design according to the local context: case of cassava flour

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The chosen case study is the production of cassava flour in Sub-Saharan Africa, because of the importance of this production and the possibilities of process optimization. In the process studied here, the roots are peeled, washed, grated, pressed, dried and ground. Drying, which is difficult to control, accounts for most of the production costs and environmental impact of processing. Mechanical dehydration has also a major role to play in limiting the drying of the product. A particular emphasis was therefore put on the simulation of dehydration so that the numerical tool proposes design solutions limiting energy consumption and, thus, improving the profitability of the units.

The simulator is structured in unit operations and developed in object-oriented programming (OOP) using open source langage Python, in order to be as generic and modular as possible. Its structure is built at the beginning of its development. All the knowledge collected and generated afterwards is aggregated in this structure. In order to describe objects of the same type in a generic way, we use structures called classes in OOP. In our simulator, there are two main classes: one for flows and one for unit operations. The inherited classes of these two classes have the same structure. The classes for the streams (i.e. product, co-products, utilities) contain their properties. The classes of unit operations contain the models as well as the economic and environmental data related to the operation. Thus, the transformation of different products, whose properties are known, can be simulated. Moreover, the simulated process can be easily modified, for example by adding unit operations whose models are known, or by changing their order. It also predicts the effluents and utilities consumption. Coupled with technical-economic data and indicators present in the classes of each operation, it predicts the costs (CAPEX & OPEX) and environmental impacts of each operation. An additional layer allows to estimate the costs of the whole transformation over one year.

Process modelling up/down scaling

Oral

Multi-physics dynamic modelling with Modelica: the study case of an experimental tomato greenhouse over a whole production season

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Mass and energy exchanges are highly coupled in greenhouse cultivation because of the plants interactions: radiative and convective heat transfers implying the canopy; latent heat and water mass transfers through the transpiration process; light absorption, carbon dioxide and dioxygen transfers through the photosynthesis and respiration processes. Indoor climate is also highly dependent on external weather due to the greenhouse structure itself: air and sky apparent temperatures, humidity, wind and solar gains. Thus greenhouse systems modelling is an intensive research topic since several decades because of this cultivation method advantages such as: crop protection against pests and meteorological hazards, better yields, easier production planning on extended periods, reduced water and treatment usage. However, heated vegetable greenhouses in Western France comes with environmental impacts due to a strong dependency on fossil-fuel energies as well as with an intrinsic vulnerability to energy costs, which question their viability. In the framework of a project aiming at the design of a new sustainable greenhouse concept adapted to the local climate (SERRES+), a system approach will be used to evaluate the performance of combined technologies including materials, energy production and storage systems, ventilation and air conditioning.

At first, a dynamic physical model of an existing experimental tomato greenhouse located in Nantes (France) has been set up using the Modelica language and open-source components libraries such as *Greenhouses* (Liege University, Belgium). In addition to existing and modified components from shared libraries, several models have also been specifically implemented: horizontal screens system, direct and diffuse irradiances management, air volumes, etc. Yearly simulations provide indicators that can be compared with experimental data recorded during an entire production period describing the indoor climate (temperature, humidity, CO2 concentration), as well as the crop evolution (harvested fruits mass, leaf surface and temperature) thanks to the embedded tomato yield model. In order to illustrate the difficulty to evaluate *a priori* the required level of details when modelling physics, the impact of more or less simplified hypotheses related with solar radiation management is shown as an example, since the latter is a predominant factor for both plant development (photosynthesis) and indoor climate (heat gains).

Oral

Infrared Process for Surface Decontamination of Dry Onions and Developing a Computational Mathematical Model for Industrial Scale Process Design

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Because of their direct consumption, microbial contamination is a crucial food safety problem in fresh foods such as fruits and vegetables. In 2020, CDC reported an epidemic and recall about Salmonella strains in dried onions, and the objective of this study was to present the use of infrared processing for surface decontamination of dry onions and develop a computational model for industrial scale process design.

For this purpose, yellow dry onions were processed at 400 °C infrared source temperature in a lab-scale far infrared (FIR) for 120 s. This process assured the surface temperature to reach to 80 °C for 2-3 log-cycle reduction of Salmonella. The experimentally obtained temperature data along the surface and interior points were used to validate the developed (using Comsol v5.6 - Comsol AB, Stockholm, Sweden) mathematical model. Then, this validated model was used to design an industrial scale infrared system heating efficiency and temperature uniformity of the processed samples.

In the industrial system designs, the effects of cavity geometry, number of infrared sources, number of onion samples and their physical movement through the cavity on the temperature evolution were determined. Rectangular and hexagonal geometry cavities, with 36, 48 and 54 infrared sources, were designed and increased amount of onion samples was processed to determine the temperature uniformity. Then, the effect of the sample movement was determined while the distance among the samples significantly affected the temperature evolution.

In conclusion, FIR processing was determined to be an efficient surface decontamination approach for dry onions. In addition, industrial scale system designs were introduced as a sustainable process with an improved temperature uniformity and heating efficiency. Hexagonal cavity system with 36 infrared sources was determined to have 2073.6 kg/day capacity.

Process modelling up/down scaling

Oral

Thermal Characterization and Efficiency Enhancement of Lebanese Bread Oven: A Comprehensive Experimental and Numerical Study

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The production of Lebanese bread encounters problems and challenges in the baking process. The Lebanese bread baking ovens have never been modeled yet. Also, the parameters for the baking process have never been studied. Reducing energy consumption while increasing energy efficiency requires a scientific understanding of the oven operating conditions and also the baking process kinetics.
This paper presents the first 3D CFD model developed for the Lebanese bread baking oven followed by experimental validation. Nevertheless, it develops a mathematical model that defines the kinetics of the Lebanese bread baking process.
A prototype of a typical Lebanese baking tunnel oven is designed and manufactured for study purposes. The prototype is equipped with appropriate measuring instruments to experimentally investigate the evolution of the oven temperatures and heat fluxes profiles at several points inside the baking chamber as well inside the dough through the baking process.
Computational Fluid Dynamics (CFD) was used to model the airflow characteristics inside the baking chamber and the non-premixed combustion occurring at the burner. Based on the simulation results the air velocity profile and temperature profile, as well as heat fluxes within the baking tunnel were established.
The predicted temperatures and heat fluxes values are in good agreement with the experimentally measured values and They showed a maximum deviation of 12%. The energy efficiency of the oven is estimated at around 16% and the energy used to bake 1 Kg of Lebanese bread is around 3.85 mJ.
A multi-phase mathematical model derived from the energy, mass, and momentum conservation principles is developed and applied to the baking process. This model is numerically simulated using (CFD) and the results are experimentally validated.
This paper is a crucial step toward oven design and baking process optimization. It is important to understand the heat transfer modes inside the baking chamber and through the baking process to provide some engineering insight in order to optimize Lebanese bread oven energy efficiency.

Process modelling up/down scaling

Oral

Scaling of continuous pulsed electric fields processes by means of dimension analysis and computational fluid dynamics

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Continuous pulsed electric fields (PEF) treatment is based on the application of high voltage electric fields (in the kV/cm-range) on a short time scale (µs-ms) to liquid food matrices or solid foods in a liquid carrier. It has recently been implemented in many sectors of the food industry, e.g., in potato processing or juice production to soften tissue, inactivate microorganisms or enhance mass transfer.
Due to the dependency of the electric field distribution on the electrode's geometry, it is difficult to transfer knowledge from one to a different treatment chamber. Also, the characteristic flow patterns and temperature profiles in a pipe have a major impact on the effectiveness of the treatment. This makes upscaling of PEF treatments even more challenging. This knowledge gap is a major limitation in the implementation of PEF in the food industry, as process safety can only be guaranteed with the help of extensive experiments.
Computational fluid dynamics (CFD) simulation based on the balance equations for mass, momentum, energy, and free charge carriers is a suitable tool for visualizing local physical phenomena and thus investigating the influence of the geometry of the PEF chamber. However, a mechanistic approach to transfer the PEF process to other scales by means of CFD simulation is still missing. Therefore, based on the balance equations, dimensionless numbers were derived for continuous PEF treatment chambers. With this, the degrees of freedom for the scale-up were determined. CFD simulations were conducted on different scales to investigate if relevant treatment parameters behave as expected. The simulations were validated experimentally, using continuous PEF systems with throughputs from 1 to 100 L/h. The proposed study revealed that effects, for example the local heating, are more pronounced on larger scales even though, the derived numbers were kept constant. This can be attributed to physical properties of the food, for example the viscosity, which again influencing the flow properties. These overlapping effects lead to non-linearities in the scale-up. This study also shows at which scales such effects must be increasingly considered and thus provides important insights for the design of safe PEF processes on an industrial scale.

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Process modelling up/down scaling

Oral

Comparison of direct numerical simulation and experimental investigation of droplet breakup inside a high-pressure homogenizer outlet chamber

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Objective

Emulsification is an essential unit operation in the food industry. High-pressure homogenizer (HPH) is the typical emulsification device used for low to medium viscosity ratio emulsions (e.g., pasteurized milk). While there is little consensus on the detailed mechanism of breakup in these devices, turbulence is considered to play a major role. This study is part of a larger project aiming for generating the fundamental understanding necessary for designing more efficient devices. The objectives of this specific study is to compare and validate the two commonly used methods for studying individual turbulent drop breakup: numerical in silico experiments and high-speed in vitro visualizations, with special emphasis on finding the limitations of the different techniques.

Methods

A cuboidal scale-up model of an HPH valve is designed and used both for the numerical and experimental investigations. For the numerical investigation of the breakup, direct numerical simulation (DNS) coupled with a highly resolved interface tracking VOF method is used. For the experimental studies, high-speed photography is carried out (using a 19000 fps camera with fluorescent marking of the drops).

Results

The results of the numerical breakup experiments are compared to the high speed visualizations in different aspects, including the position and the morphology of the breakup. The main limitations of the in vitro high-speed visualization technique are in only allowing for the investigation of a 2D-projection of the drop and in a limited spatial and temporal resolution. The main limitation of the numerical in silico experiment is in only allowing for a relatively simplistic description of how surface active species interplay with external stress (i.e., assuming an interfacial tension that is constant over space and time).

Conclusions

The combination of numerical experiments (high temporal and spatial resolution) and high-speed visualizations provides a powerful approach for studying the mechanism of drop breakup in turbulent emulsification devices. The verification of the DNS results by the experiments paves the road to use the detailed information provided by the DNS to study breakup on modified designs impossible to study by the experimental framework (i.e., in the axisymmetrical geometry of a production scale HPH).

Process modelling up/down scaling

Oral

A fundamental understanding of drop breakup in emulsification devices brings new hope for lowering the energy cost of homogenization

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Objective
Emulsification–via rotor-stator mixers (RMSs) or high-pressure homogenizers (HPHs)–is an important unit operation in the industrial production of many foods and beverages, e.g., milk and mayonnaise. These processes, however, suffer from high energy cost and low thermodynamic efficiency. A deeper understanding of drop breakup in these devices will lead the way to more efficiency designs. Previous investigations show breakup occurring due to turbulent stresses. Less is known about details of the role of turbulent eddies in food emulsion drop breakup. The aim of this study is to provide a detailed understanding of how turbulent eddies break emulsion drops in food emulsification by HPHs and RSMs.

Methods
Numerical breakup experiments (direct numerical simulations coupled to highly resolved interface tracking) are used to study individual drops subjected to either idealized turbulence (isotropic, homogenous) or the turbulence of a confined wall-interacting jet (resembling the turbulence in a RSM or HPH). Conditions are set to resemble breakup of a milk globule in a HPH. This method allows for an almost full characterization of morphology during deformation, as well of the stresses acting on the drop from turbulent eddies, with high spatial and temporal resolution.

Results
Drops show distinctively different breakup morphologies depending on their Weber number, i.e., large milk drops entering the homogenizers break from a different mechanism than the drops just large enough to break. The limiting drop (determining physical stability of the emulsion) breaks from a bulb-neck mechanism– turbulent eddies deform the drop until a neck forms separating two bulbs. Once the curvature of the neck exceeds that if the smallest bulb, the internal flow becomes destabilizing, leading to deterministic breakup. The sequence of interactions leading to this state is highly stochastic and requirea several individual drop-eddy interactions.

Conclusions
Due to a combination of numerical breakup experiments (this study) and high-speed visualizations (previous and ongoing studies), the mechanism of turbulent breakup in these commonly used food processing unit operations is now relatively well understood. Knowing where and how breakup takes place gives now opportunities for redesigning HPHs and RSMs so as to reduce the energy cost.

Process modelling up/down scaling

Oral

A mathematical model to predict the release of encapsulated food active compounds from viscoelastic matrices

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In the food industry, encapsulation is used to protect and deliver active compounds (probiotics, essential oils, vitamins, etc.), which are sensitive to normal processing, storage, transportation, and digestion conditions. An adequate encapsulation of these active compounds can prevent their degradation, increasing their stability and bioavailability and ensuring their controlled release at the right time and site. In this regard, mathematical modelling of release kinetics could be a useful tool for the development and/or optimization of encapsulation systems, since it would help to minimize the number of experiments, experimental time, and costs. The objective of this work was to obtain and validate a mechanistic mathematical model to predict the release kinetic of encapsulated food active compounds.

The system consisted of a particle surrounded by liquid, composed of an active (dissolved and non-dissolved), water (present in the matrix and the surrounding liquid), and an encapsulating matrix. The model assumed that the water of the surrounding liquid can diffuse into the particle, causing the dissolution of the non-dissolved active, the diffusion of the dissolved active, the degradation of the matrix (erosion), and the development of stresses in the matrix (swelling). Characteristic dimensionless parameters related to the described phenomena were obtained. Model validation was carried out to evaluate the descriptive capacity of the experimental data of the in vitro release of astaxanthin encapsulated in calcium alginate beads.

A mean absolute percentage error less than 10% was obtained. The validation step was complemented with the experimental determination of model parameters related to the molecular weight of encapsulating matrix, the diffusion coefficient of water in the matrix, and the depolymerization kinetics of the matrix in simulated intestinal conditions. These values were used for estimating characteristic dimensionless parameters and specific values of the studied system.

The results showed that the proposed model can describe the release kinetics of active encapsulated compounds and it could be used to design and optimize food encapsulation systems.

Process modelling up/down scaling

Oral

An Innovative Approach for De-Crystallization of Honey by Radio Frequency Heating: Computational Monitoring of Process Efficiency

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Industrial de-crystallization of honey is carried out using conventional methods of hot water (12-18 h at 60 °C) or air (24-36 h at 60 °C) with the cost of energy and process time. Radio frequency (RF) process, with its longer penetration depth and volumetric heating feature, is an innovative approach to increase process efficiency. It might be used for honey de-crystallization. However, monitoring the de-crystallization process is important for sustainability and efficiency since even the presence of smaller crystals might lead to further re-crystallization during storage. Therefore, the objectives of this study were to introduce RF de-crystallization and monitor this process with time-domain TD-NMR for crystal size and content of honey samples.

For this purpose, pine honey samples were used in a staggered through electrode configuration (10 kW - 27.12 MHz) RF system. Temperature change of honey samples was recorded during the process at 15 cm electrode gap and 5000 V potential. This data was used for validating the computational model (developed for honey de-crystallization using Comsol Multiphysics V5.6). TD-NMR experiments were, on the other hand, performed to monitor the de-crystallization at 40 to 70 °C with a magnet operating at 20.34 MHz. Relative crystal contents (for fine and coarse crystals) were recorded using a solid echo pulse sequence.

Experimental TD-NMR data was used to determine D- and z-values of the de-crystallization process, and these kinetic parameters were coupled with temperature change during RF processing. The results demonstrated the NMR monitoring for RF processing while the experimentally validated computational model well determined the required process time. TD-NMR data enabled further determination of crystal amount through the process. Use of RF processing led more than 50% reduction in de-crystallization time for 20 kg samples in an industrial scale process compared to conventional approaches.

RF heating for honey de-crystallization was demonstrated as an efficient and possible sustainable industrial processing.

Oral

Accounting for uncertainty and variability in food processing and post-processing kinetic calculations: the case of nutritional deterioration in fruit and vegetable products

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During fruit and vegetable processing and subsequent storage/handling, bioactive compounds, such as vitamins, are prone to degradation, with temperature being the main quality loss rate determinant. Such nutrients are frequently applied as quality indices of products from production to final use and serve as design criteria of both processing (conventional or novel) and subsequent food chain. In an integrated approach, quantitative assessment of the effect of processing and post processing parameters on nutrient stability, enables optimization of the relevant stages of product lifecycle. This can be implemented by using alternative mathematical approaches of various complexity ranging from the typical deterministic kinetic analysis to stochastic approaches incorporating parameter uncertainties and inherent variabilities.
The objective was to estimate nutritional degradation and approach product quality and shelf life calculations through an integrated scheme, based on Monte Carlo and Bayesian principles, accounting for kinetic parameter uncertainty and material/process/distribution/storage variability during actual product lifecycle. The stochastic approach for process optimization and effective management is demonstrated via case study computations, based on experimental data, on representative thermal and nonthermal processes of alternative fruit/vegetable products and Vitamin C as the target nutrient index.
The presented case involved high pressure processing (600 MPa, 40°C, 4 min) or thermal pasteurization (80°C, 60 s) of refrigerated Navel orange juice, followed by a kinetic study of post processing nutritional degradation. In the Bayesian analysis a distribution was used to describe each kinetic parameter. Additionally, Monte Carlo simulations were implemented to account for statistical uncertainty and/or variability, such as various temperature conditions reported in the actual cold chain, retrieved from a big data base. Results showed that orange juice products optimally processed, either thermally or by high pressure, maintained acceptable Vitamin C content (up to 50% loss) for a shelf life expressed by a distribution in the 50-65 d range, vs 100-115 d, respectively, taking into account mathematical uncertainty and food chain variability. In comparison to the respective single value estimates of 60 and 110 d, based on fixed parameter values and constant temperature conditions, the distributions obtained by stochastic approaches more realistically depict the expected product quality variation.

Process modelling up/down scaling

Oral

Elaboration of cereals and legumes-based extruded foods guided by rheology and simulation

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Many starch-based foods, such as textured ingredients, breakfast cereals, snacks, and more, are produced by extrusion. However, there is a growing interest in developing sustainable agriculture and diversifying the supply of healthy and balanced foods from local legumes. Legumes, composed of proteins (20-30% dry basis), dietary fibres (10-30%) and starch (40-50%), and low in sugar, unsaturated fat and sodium, are a sustainable source of nutrition for human consumption and can also be used as a natural nitrogen fertilizer. Despite nutritional advantages of legumes (high protein content, low glycemic index) over their grain-based counterparts, extruded legume-based foods are still rare. Despite significant advances in extrusion modelling and simulation, the design of extruded products at the industrial level still relies on trial and error approach.

A global 1D twin-screw extrusion model, implemented in a simulation software, Ludovic®, was used to predict flow variables along the screws and die, and to design different starchy products with targeted structure and properties. An experimental database has been compiled with seven formulations for manufacturing extruded foods from starches, breakfast cereals, legumes flours such as pea and fava bean, and bran-enriched wheat flour. This database includes thermal and physical properties of solid and molten states, melt viscous behaviour model, and experimental results on extrusions, such as extruder's configurations and operating conditions, and structure and properties of extruded foods.
The extrusion model satisfactorily predicted product temperature at the die exit (T) and Specific Mechanical Energy (SME).

A sensitivity analysis of flow variables (T, SME, viscosity) at the die exit was carried out on the formulation, extruder's configuration and operating conditions, generating extruder's working charts. The results established satisfying relationships between the predicted flow variables and product features such as structural changes of starch and protein, structure (density, cellular structure) and functional properties. Extruder's operating conditions leading to targeted food features can be assessed from these relationships. The satisfactory correlations justified the use of the extrusion model as a computer-aided tool for designing starchy foods by extrusion. Moreover, the capacity for predicting food features is extremely vital to reducing time and labour costs in industrial foods R&D.

Process modelling up/down scaling

Oral

Lattice Boltzmann model of the flow of meat analogs through extruder die

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Given the growing demand for plant-protein based meat replacers, there is continued research towards their manufacturing by means of high moisture extrusion for several decades now. Due to the complexity of the extrusion process, and the rheology of the plant protein dough, there is still little understanding of which physical processes underly the anisotropic structuring of meat replacers. To advance this understanding we have developed a flow model describing the flow of a yield stress fluid through the cooling die, attached to a twin screw extruder.

Our rheological measurements [1] has shown that the protein dough is behaving as a Herschel-Bulkley fluid, exhibiting a yield stress and shear thinning. Furthermore, it is shown that the variations of yield stress and critical shear rate follows a scaling with Tg/T, the ratio with the moisture dependent glass transition temperature and the actual temperature (in Kelvin). The shear-thinning exponent is independent of material conditions.

To describe the flow in the extruder die, we have developed a Lattice Boltzmann model, solving simultaneously the flow field and the temperature field. Furthermore, we have incorporated wall slip in the model, which is shown crucial for the process – as the material exits the die as a single plug – with shear-flow only in a lubrication layer along the wall. The choice of Lattice Boltzmann is done, because the future extension of the model towards the mesoscale structuring, as observed by Wittek [2]. We view this process akin to syneresis, which can be modelled similar to viscoelastic phase separation [3].

In this contribution, we give a detailed description of the model, and show results of a parameter study – showing how flow profiles and pressure drops depend on rheological properties of the protein dough.

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Process modelling up/down scaling

Oral

Effect of morphological features on the mechanical properties of extruded pea snacks: finite element modelling

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Extruded foods from pulses can be envisaged as solid foams with cell walls are considered as a dense starch-protein composites. Pea flour (PF) and blends of pea starch and pea protein isolate (PPI) with different protein contents (0.5-88% dry basis) were extruded to obtain models of dense starch-protein composites. Their morphology was revealed by CLSM microscopy, and their mechanical properties were investigated using a three-point bending test complemented by Finite Element Method (FEM) modelling. Composite morphology revealed protein aggregates dispersed in the starch matrix. It was described by a starch-protein interface index Ii computed from the measured total area and perimeter of protein aggregates. The mechanical test showed that the extruded PF and PPI ruptured in the elastic domain, while the extruded starch-PPI (SP) blends ruptured in the plasticity domain. The mechanical properties of pea composites were weakened by increasing the particle volume fractions, including proteins and fibres, probably due to the poor adhesion between starch and the other constituents. The mechanical behaviour of pea composites did not accurately follow simple mixing laws because of their morphological heterogeneity. Modelling results show that the elastoplastic constitutive model using the Voce plasticity model satisfactorily described the hardening behaviour of SP blend composites. Reasonable agreement (2-10%) was found between the experimental and modelling approaches for most materials. The computed Young's modulus (1.3–2.5 GPa) and saturation flow stress (20-45 MPa) increased with increasing Ii (0.7-3.1), reflecting the increase of interfacial stiffening with the increase of contact area between starch and proteins. FEM modelling was shown to be a relevant approach to consider the microstructure heterogeneity of starch-protein composites.

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Process modelling up/down scaling

Poster

Effects of the Orientation and Geometry of the Potential Applied Electrodes on Radio Frequency Heating

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Effects of the Orientation and Geometry of the Potential Applied Electrodes on Radio Frequency Heating

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Keywords: Microwave systems, mathematical modelling, manufacturing and thermal processing.

Radio frequency (RF) is assumed to be a volumetric heating process with its efficiency for shorter process times and better quality compared to conventional approaches. Through field parallel plate electrode type is commonly used in pilot and industrial scale systems for various thermal processing. Besides the parallel plate electrodes, where the top electrode is potential applied, through field staggered electrode systems, where the potential applied set might be bottom or top, are also used. Use of fringe field electrode types are other systems depending upon the size of the sample.

To compare these various electrode systems, a computational mathematical, developed (using Comsol V5.6, Comsol AB, Stockholm, Sweden) and validated with experimental data, were used for comparing the evolution of electromagnetic field and temperature distribution for an industrial scale thawing process.

Through field parallel and staggered electrode types were determined to be efficient for processing large sized bulk products while small sized lower thickness products were better to be processed in fringe field electrode configuration systems. The heating rate in the through field parallel electrode systems was the highest even at the same potential applied in the staggered through field cases. Local undesired high temperature evolution was observed in the fringe field electrode type systems, and hence a physical movement of the sample was specifically required compared to the other systems.

Electrode orientation and geometry in RF systems were determined to significantly affect the electromagnetic field distribution and resulting temperature evolution. It was rather important to decide upon the Rf system depending on the geometrical features of the samples for obtaining a uniform temperature distribution. Effect of the various configurations are required to determine in successive multi-cavity systems for sustainable processing.

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Process modelling up/down scaling

Poster

Novel technology in high moisture extrusion for customized and controlled plant protein-based meat alternatives production

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Keywords: Processing, Plant protein-based meat, High moisture extrusion, Rheology, In-line sensing, Spectroscopy, Process control,

In the context of making a more sustainable future for food production, High Moisture Extrusion Cooking (HMEC) technology is gaining interest as it can be used to develop plant-based food alternatives with reduced environmental impact. HMEC enables to produce fibrous structures from plant proteins mimicking the meat texture, which can be further enhanced with sensory and nutritional quality characteristics, representing the base on which new technological approaches to generate plant-based meat alternatives can be built. In order to bring the HMEC process at the level of making sustainability impact, unlocking the next level of autonomy and reliability, a novel technology development for measuring and controlling the process-structure-product characteristics is presented. In a first step, several in-line techniques were integrated/developed to measure at micro-, meso-, macro-scale the protein melt and extrudate properties. An in-line process analytical-measuring toolbox based on RAMAN/FT-NIR spectroscopy and slit die rheometry was deployed on an extruder to identify protein structural changes and to derive the viscoelasticity of the melt, respectively. Subsequently, a closed-loop control framework is established by coupling pre-selected in-line sensing systems with predictive algorithms. The approach enhances the previously introduced processing procedures for HMEC such as (1) Micro-Foaming, (2) Pore-Opening and (3) Pore-Filling, which allow tailoring of the plant-based meat alternatives to consumers' needs in terms of texture and fortification. With the proposed technology the production of plant-based meat alternatives can be upscaled while keeping the meat-like fibrillar structure formation and textural sensory parameters at the desired level. Advantages and practical feasibility of the approach are successfully demonstrated on a pilot-scale extruder.

Poster

Hybrid Mixture Theory Based Unsaturated Transport in Foods During Drying and Freezing Applications

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During applications such as drying and freezing of foods, fluid transport is of unsaturated type due to the involvement of the gas phase (air-vapor mixture). Unsaturated transport is significantly more complex than saturated transport as the gas phase is compressible, leaks through pores, and results in capillary forces at the fluid interfaces. In addition, many foods undergo glass transition during the process. Near glass transition, biopolymers relax at the same time scale as diffusion time. Thus, three predominant forcing terms affecting unsaturated fluid transport in foods undergoing glass transition are—concentration gradients (e.g., moisture/plasticizer gradient), pressure gradients in various phases, and strain gradients in biopolymers. This presentation will discuss the generalized Darcy's law and other fluid and species transport relations derived using the Hybrid Mixture Theory of porous media, which includes these forcing terms. A solution of the generalized Darcy's law for drying and freezing applications will be presented. Coupling of the fluid transport equations with species transport equations for foods subjected to freeze-thaw cycles and calculation of the freezing point depression will be discussed. Simulation results on the opening and closing of freezer doors on temperature fluctuations and ice formation inside the food will be presented.

Process modelling up/down scaling

Poster

Infrared Surface Decontamination of Whole Shell Eggs - Mathematical Modeling for Process and System Design

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Microbial contamination of daily products especially fresh whole shell eggs has been a common food safety problem. While the interior of the egg is assumed to be safe as long as they are obtained from healthy poultry, eggs can easily be subject to microbial contamination. This surface contamination might then penetrate through the shell and cause deterioration during the storage.
Hot water pasteurization is currently applied in industry for surface contamination, but this cases a significant wastewater and possible cross-contamination problems. Far - Infrared radiation technology is a novel method which is commonly preferred with its low penetration ability and suitability for the surface decontamination process while it also offers a high energy efficiency.
In this study, a mathematical model to determine the surface temperature of whole shell eggs was developed using COMSOL Multiphysics v6.0 (Comsol AB, Stockholm, Sweden) and experimentally validated. The experimental studies were carried out in an 18-seramic far infrared source batch and 4-source continuous pilot-scale system. A black aluminum object (with the emissivity value of ≈1) was first used to determine the system surface parameters, and then the egg surface temperatures were determined using type-K 36 gauge thermocouples. An infrared camera was also used to determine the surface temperature distribution.
Following the model validation studies, various processing possibilities were explored for industrial scale systems in tunnel designs.
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Process modelling up/down scaling

Poster

Radio Frequency Heating Process for Infant Formulas and Developing a Computational Mathematical Model for Process Design

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Due to direct consumption and sensitive consumer profile, microbial evolution has been a significant problem in infant formulas. In 2022, according to CDC reports, Salmonella infections have been detected in certain formulas of recalls and causes of health issues. Considering that the conventional thermal processing approaches might not be effective, the objective of this study was to develop a radio frequency (RF) heating process for decontamination of infant formulas.

RF heating experiments were carried out in a free oscillating (staggered through electrode) pilot plant scale RF system (27.12 MHz, 10 kW). The infant formula samples (400 g) were purchased from a local store (Ankara, Turkey) and placed in a polypropylene container to process in various electrode gap and power levels until the surface and mid-point temperatures reached to 65 °C. The optimum process condition was at 10 cm electrode gap and 2500 V potential of the charged electrode at 25-30 min heating time.

Following the experimental studies, a mathematical model was also developed using COMSOL Multiphysics v6.0 (Comsol AB, Stockholm, Sweden), and the experimental data were used for model validation. Then, various processing possibilities with respect to the size of the samples were demonstrated in an industrial scale RF heating process.

As a conclusion, RF application showed a significant possibility for processing of infant formulas while the further quality related studies with microbial inactivation kinetics are required.

Process modelling up/down scaling

Poster

Integrating food extrusion research and expert knowledge to elucidate insightful relationships and enhance predictive modelling

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An increasing volume of research is being published within the scientific literature regarding food production through twin-screw extrusion, with research interest set to rise with consumer demand for novel food products such as plant-based meat analogues and healthy snacks. Increased demand necessitates industrial scale up of extruded food production, which creates numerous operational challenges. Food extrusion is still largely considered as a 'black box' process, where scale up and process optimisation is predominantly conducted through a trial-and-error approach. In response to this challenge, process modelling for twin-screw extrusion has been developed over the past 40+ years with the potential to streamline product development and optimisation through predictive capability. However, existing modelling techniques are still significantly limited to idealised processing conditions and simple product formulations. To address these limitations, research work is required to broaden the scope and applicability of food extrusion modelling techniques through the empirical understanding of food property evolution through the twin-screw extrusion system for novel product formulations, and the incorporation of non-Newtonian rheological models that more accurately represent material flow and deformation under high temperature and high shear conditions. An important first step to achieve these goals is to map and integrate the current state-of-the-art for the field of food extrusion across both the academic and industrial contexts, so as to extract insightful relationships between important system parameters. As such, this poster presentation will outline our approach to integrate the rapidly expanding research field of food extrusion through the development of an expert knowledge system to highlight industrial expertise, and an interactive research database comprising a summary of the key food extrusion literature. Lastly, this poster will identify the existing modelling techniques for food extrusion, outline the assumptions and gaps still present within these approaches, and signal how existing and emerging knowledge in both academic and industrial contexts can be incorporated into these modelling techniques to broaden their scope and improve their predictive capability.

Poster

Progress in predicting internal and external cleaning by computational fluid dynamics

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In the food industry, regular cleaning of production equipment is essential to ensure product quality and food safety. Efficient cleaning processes have the potential to increase the availability of the machinery while decreasing resource consumption. Recently developed, efficient models for the numerical simulation of cleaning processes promise a real optimization of these processes. The continuously increasing availability of computational resources and ongoing improvement of simulation models as well as characterization methods enable a prediction of cleaning performance for design purposes. Here, we demonstrate two methods for the simulation of internal and external cleaning.

In the first approach, the cleanability of film-like soils in macro-structured pipes is evaluated qualitatively as a function of the relevant cleaning mechanisms and relative to a reference component. The flow simulations in ANSYS Fluent are based on the Reynolds averaged Navier-Stokes equations and the soil behavior is modelled as a boundary condition leading to calculation times suitable for industrial applications. Different geometry variations of dimples and protrusions on the pipe surface are investigated and discussed. Through the subsequent geometry optimization of the structures, the macro-structured surfaces outperform a straight pipe in terms of fouling mitigation as well as macroscopic and microbial cleanability. Experimental cleaning tests serve to confirm the simulation results and assess the approach for a generalized evaluation of cleaning performance.

The second approach discusses the simulation of automated spray cleaning. Instead of the standard grid-based methods, the highly efficient grid-free simulation software MESHFREE is used. It is based on a Generalized Finite Difference Method and relies on the consideration of a numerical point cloud representing the continuum. The 3D simulation of the spray jet is combined with a simplified 2D model near the wall. It uses the shallow water equations to describe the flow in the resulting thin fluid film on the surface and subsequently optimize the cleaning effect. The validation of the flow simulation is based on extensive flow measurements. Cleaning experiments and parameter studies in the simulation are also used to determine correlations between mechanical stress and cleaning effect of discontinuous, moving spray jets.

Process modelling up/down scaling

Poster

Modelling bacteria inactivation during the steaming process: application to Cambodian pâté pasteurization

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Cambodian pâté is a popular food that can be found in every market throughout the country but its consumption is associated with a substantial proportion of food-borne illnesses. Traditionally this product is made by blending meat with a variety of ingredients and cooked using steam. A common issue found in the steaming process is the heterogeneous temperature distribution, which limits microbial inactivation within the product. The present work aims to model heat transfer and microbial inactivation during the pâté steaming process and to validate them by challenge test experimentations.

Numerical simulations of the steaming process were performed with COMSOL®Multiphysics 6.0. The remaining bacteria after treatment were assessed from a microbial inactivation model for three key bacteria: Listeria inocua, E. coli and Salmonella typhimurium. Model validation was done with an innovative challenge test design where the inoculated pâté is loaded into inoculum tubes placed at the center and periphery of a cylindrical cell which contains the raw pâté (TB zone for the bottom of the cell and TH for the top). Temperature profiles were recorded for each zone throughout the treatment and the pâté sample was heated until the temperature at the center reach 55oC, 57.5oC and 60oC. The inoculum tubes were then cooled down immediately and the remaining bacteria were quantified.

When the temperature of the steam is 98oC, it took 16 min, 24 min, 25 min to increase the temperature at the center from around 10oC to 55oC, 57.5oC, 60oC respectively. The model depicts the temperature gradients between the cold and hot spots decreasing along with the increasing temperature at the center of the sample. After 57.5oC treatment, remaining bacteria at the center (TB and TH) were evaluated around 3 to 4 log cfu/g (initial amount of 7 log cfu/g). An undetectable amount of bacteria was obtained for treatment higher than 60oC for the three bacteria.

The experimental results were found in agreement with the modelling approach and highlighted the suitability of the suggested innovative cell design to support the setting of heat treatment parameters as well as the benefit of combining heat transfer model and microbial inactivation.

Process modelling up/down scaling

Poster

Use of Toroidal Cans in a Microwave Pasteurization Process: A Computational Study with Experimental Validation

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Canning is a highly preferred thermal processing approach with its versatile use and resulting long shelf life of food products. Heat transfer occurs by conduction for solid foods while convection is more dominant in liquid and solid-liquid mixture products. Due to the constraints in the process and geometry of the cans, the applied rotational and agitational processes are so far the only innovations in canning. Toroidal cans are the recent presentation to increase the heat transfer rates and reduce the process time while microwave (MW) processing has an increased applications in the food processing with its volumetric heating feature.

Therefore, the objective of this study was to apply toroidal cans (manufactured from polypropylene) in a MW application for an efficient processing.
For this purpose, toroidal cans with 73 mm diameter and 110 mm length were manufactured from polypropylene, and distilled water (low viscosity Newtonian liquid) and 0.5% CMC solution (high viscosity non-Newtonian liquid) were processed in a lab-scale 1 kW MW system. During this process, temperature measurements were obtained using fiber optic sensors, and this data were used to experimentally validate the mathematical model developed using Comsol v5.6 (Comsol AB, Stockholm, Sweden). Then, the validated model was used for various process design approaches for MW processing including rotational effects.
This study demonstrated an innovative process for canning with increased heat transfer and temperature evolution efficiency. This novel approach might be a possible sustainable process for future canning industry.

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Process modelling up/down scaling

Poster

Characterization of methods to better understand the parameters influencing the Hard To Cook phenomenon

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Characterization of methods to better understand the parameters influencing the Hard To Cook phenomenon.

In addition to the environmental benefits of restoring nitrogen to the soil without adding fertilizer, legumes offer significant nutritional benefits. However, one of the difficulties encountered in the processing of legumes in industry is the so-called "Hard to Cook" phenomenon.

This study aims to remove the scientific barriers to understanding the Hard to Cook phenomenon. The " red bean " matrix is chosen as a model for this study.

In order to maximize the reliability of the analytical results, the study was carried out on 4 selected red bean batches: 1 control batch from France with Easy To Cook propensity and 3 batches with Hard To Cook propensity.
These batches of kidney beans were also stored under temperature and humidity conditions that favored the development of the Hard to Cook phenomenon. This was done in order to have the most contrasted batches possible.

During this project, the modeling of hydration kinetics, the analysis of mass densities, the porosity of seed structures, the composition of layers within the seeds, the fraction of soluble pectins were carried out and allowed to correlate the Hard to Cook phenomenon to the beans composition and especially its structure.
These analyses on the biochemical mechanisms and on the determination of the hydration and water diffusion kinetics, allowed to contribute to a better understanding and to orientate towards detection and sorting methods of Hard To Cook beans

Data analysis on the spectral part seems promising. The PCAs of the hyperspectral images show that the control batch seem to imbibe more rapidly than the Hard To Cook batches. This is consistent with observations of DCS and sigmoid hydration curves.

A portable infrared spectrometer (MicroNIR) was tested to study the Hard To Cook criterion. The study of the results by Principal Component Analyses showed that this equipment seems able to differentiate Hard To Cook seeds incorporated among control seeds. However, further studies are needed to validate the ability of this equipment to classify Hard To Cook or Easy To Cook seeds with sufficient robustness.

Poster

MODELING HEAT AND MASS TRANSFER DURING PORK LOIN COOKING IN AN ELECTRIC OVEN

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The meat cooking process involves heat to transform the raw muscle into safe, nutritious, and tasty food. This work aimed to model and validate pork loin roasting in a commercial electric oven. For that, pieces of pork loin were cooked in a controlled cavity with natural convection, and the transport phenomena were modeled using a system of partial differential equations. The model includes thermal radiation and heat convection between the food surface and oven ambient, and, inside the meat, heat conduction, moisture diffusion, and pressure-driven water flow. The 3D mathematical model was solved numerically by the finite element method and validated using experimental data of temperature and moisture content in the product during roasting at 180, 200, and 220 ºC, achieving good RMSE values. As expected, the oven temperature influenced the temperature and moisture content profiles during the roasting process. The time needed to reach the safe cooking temperature recommended for pork meat of 71.1 ºC at the center of the sample was shorter as the oven temperature increased, changing from around 16.33 min at 180ºC to 13.33 min at 220 ºC. In addition, the meat emissivity, convective heat transfer coefficient, permeability, and diffusion coefficient were estimated to feed the model for numerical simulations. The model provided detailed information about the product's transient temperature, moisture, and pressure distribution and demonstrated that dripping was the main mechanism behind moisture loss during meat cooking. A sensitivity analysis also indicated that the relative humidity inside the oven is a key parameter in the roasting process, impacting the meat moisture loss and cooking time. The present study is useful in understanding the physics of meat cooking and can be used for case studies since the mathematical model well describes the heat and mass transfer dynamics in the process. Thus, its use supports quality control during cooking, such as observation of temperature evolution and mass loss, and be coupled with quality kinetics to predict color, texture, microbial inactivation, and shrinkage.

Process modelling up/down scaling

Poster

Optimization of Radio Frequency Thawing Process Parameters in Frozen Bulk Chicken Thigh Meat

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Recent studies demonstrated that radio frequency (RF) processing might be effectively used for thawing by decreasing process time, saving energy and minimizing the quality changes. In this study, experimental optimization of RF thawing of frozen chicken thighs, in retail package and commercial sizes, was carried out in industrial scale conditions.

Thawing experiments were carried out in a free oscillating pilot scale RF system (10 kW, 27.12 MHz), and frozen samples (retail package ~1 kg and commercial bulk size ~9 kg in a 60×40×10 cm box) was processed in five different electrode gaps (8, 10, 11.5, 12, 17.5 cm) and two power levels (2000 and 3500 V) to determine the optimum process condition. Time dependent temperature changes within the samples were measured with fiber optic sensors during the thawing process. The target temperature was average ≈-1 °C along the cold region. Following the experiments, mathematical modeling studies were also carried out, using COMSOL Multiphysics v5.6 (Comsol AB, Stockholm, Sweden) using the enthalpy method to better predict the phase change. Experimental results were used for model validation, and the validated model was further applied for various industrial scale process cases to improve the process efficiency.

The experimental results indicated that the optimum condition was 8 cm electrode gap at 3500 V potential and 17.5 cm electrode gap at 2000 V for retail and commercial sizes, respectively. These setting were also confirmed with the developed model for temperature uniformity. Various geometrical orientations were also demonstrated for process efficiency where higher loads were thawed with the similar potential appliances.

In conclusion, RF processing was suggested as a promising technique for efficient thawing of frozen chicken thigh meat bulks with an improved temperature uniformity and efficiency as a sustainable process.

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Poster

Data-driven reduced order modelling for crystallization processes

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A wide range of manufacturing methods and applications in food processing involve crystallisation processes. As crystal/microstructure formation determines both quality and function of frozen and freeze-dried products, a proper control of crystallisation conditions during processing is critical. In this context, mathematical models can help to design and optimise efficient crystallisation industrial processes.

However, these current approaches used to model crystallization processes usually lead to computationally involved numerical schemes, revealing the need for more efficient computational solutions: i.e., industrial applications, like real-time control and optimisation, require the development and implementation of process models that are capable to operate at faster time scales than the process itself.

In this work, we considered a Phase-field model that couples heat and mass transfer phenomena and describes the evolution of the solid/liquid interface, to describe and predict ice crystal formation in food model systems. Using this Phase Field model as reference, i.e., full model, we have then compared the performance of different data-driven methods: (i) Proper Orthogonal Decomposition (ii) Dynamic Mode Decomposition and (iii) and Deep Learning-based model reduction under a range of undercooling and seeding conditions.

Results obtained showed that data-driven reduced models, some of which include physics and process dynamics information, can describe the behavior of the crystallising system, including the effect of the degree of supercooling on the formed crystals morphology, accurately while reducing associated dimensionality and computational times.

Overall, this work demonstrates the potential of reduced order approaches for the modelling of phase change processes and also for the development of virtual tools that allow a “fast” (yet accurate) monitoring, design and optimisation of food manufacture operations, enabling a “real-time”, I4.0 framework in the food processing sector.

Poster

Predicting performance of cooking ovens: A simulation-based design

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Research Justification

Convection ovens provide a versatile way of cooking different food groups in households and professional kitchens. However, their thermal efficiency is very poor (about 13%). Oven cooking involves coupled radiative and convective heating of food as a porous material, which undergoes a complex thermophysical transformation. Engineering understanding of the energy fields in an oven is limited, making it challenging to design smart, energy-efficient ovens that provide the desired performance metrics of cooked food; such design ends up largely based on trial-and-error.

Objective

To provide a mechanistic understanding of the effect of oven parameters (broil/bake/convective heating element temperatures, air flow rates, position of racks/food in multi-rack cooking, duty cycle) on the food boundary conditions deciding the success of cooking.

Methods

A physics-based computational model for a conventional oven with conduction, convection, and radiation modes of heat transfer is developed. The coupled system of governing equations for multicomponent, multimode heat transfer and fluid flow inside the oven cavity is solved numerically. The model predicts the evolution of wall temperatures, air temperatures and air velocities inside the oven cavity during the preheating and cooking cycle. The oven model is validated by comparing the predicted cooking metrics (desired air temperatures, air velocities, radiative heat flux) against measured values.

Results

The predicted wall temperatures, air temperatures and air velocities inside the oven cavity for preheating and cooking cycles agreed very well with the experiments. The air temperatures inside the oven cavity showed nearly 40°C variations and were stratified with higher temperatures close to the bottom surface. The radiative heat from the bottom wall was 37% more than the top wall inside the oven cavity. The model showed that the middle rack was the most optimal cooking rack with desired air temperatures. The size of the optimal cooking zone was reduced with a higher thermal (food) load.

Conclusion

The model enables a detailed quantitative understanding of the influence of oven parameters on cooking metrics, thus providing a rational basis for design change. The mechanistic model will allow more efficient design and optimization of ovens, reducing time to market, and enabling novel improvements.

Process modelling up/down scaling

Poster

The effect of bubble distribution inside a food fermentor

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Aerated food fermenters will be more frequently used in the future in the food industry. Inside these aerobic fermenters the dissolution of oxygen to the fermentation broth is important for the efficient operation of the reactor. Therefore, to make accurate designs for fermenters the local oxygen levels including complex liquids under turbulent conditions needs to be modelled. In this study, the application of Computational Fluid Dynamics (CFD) to aerobic fermentations are investigated when varying parameters such as bubble distribution for different operating conditions of fermenters and investigate the interactions between mixing and oxygen transfer limitation.

Process modelling up/down scaling

Poster

Experimental validation of the Navier-Stokes-Cahn-Hilliard equation and prediction of phase separation time

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One of the challenges for the modelling of the phase separation of emulsions are the ostwald ripening and the coalescence stages. To this respect, the mathematical framework developed by Cahn and Hilliard (1958) has several advantages with respect to other approaches such as population balance or kinetic equations: I) it is a mechanistic framework, which means that the parameters required to describe the phase separation (surface tension, interphase thickness, mobility) have a mechanistic meaning ii) it can be coupled with the Navier-Stokes equation, which would allow its use for the development of digital twins iii) on its most basic standard 2D formulation, its resolution yields a very intuitive graphical representation of the phase separation phenomenon.

As of today, there has been an extensive amount of theoretical work on the basis of this framework, for very different fields (e.g. polymer science, metallurgy, cancer research). Nevertheless, and at least for food-related applications, it does not seem to have been validated experimentally. Reasons behind this are the equation structure, which requires non-standard numerical schemes in order to perform acceptably without the need of significant computing power; as well as the need of an extra data extraction procedure that allows to compare the numerical to the experimental data.

The goal of the ongoing work is to provide experimental validation of the Cahn-Hilliard and the Cahn-Hilliard-Navier-Stokes frameworks for different systems. This will enlarge the currently non-existing parameters database, so that these frameworks become the standard to predict the stability of emulsions.

Poster

Hydration effect on dough behaviour during mixing by assessing the power curve

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The breadmaking quality is highly governed by the properties of wheat flour because it is the main component in dough, and its hydration capacity is crucial to determine dough properties. Understanding this phenomenon would allow to predict dough rheological properties during its mixing at several hydration levels. This behaviour was characterised by following the mixing power curve P(t), modelled by a Gaussian law. The purpose of this work is to study the effect of the dough hydration level on the dough behaviour during mixing by assessing P(t). So, the mixing behaviour of wheat flour doughs prepared with different hydrations was compared.

Two commercial wheat flour, discriminated by their protein content and known to have distinct mixing behaviour were selected. Doughs were prepared in the laboratory spiral mixer (Diosna Gmbh) for 15 min, at five different hydration levels (from 50% to 66% by weight of flour, with a step of 4%). The power curve was fitted to determine the four coefficients of the Gaussian model: *Pmax – P0* (W), *P0* (W), *ST* (s) and *TPmax* (s).

For the two flours, *Pmax – P0* (W) and *ST* (s) linearly increased from 30 W to 80 W and from 10s to 35s respectively ($R^2 = 0.99$), and *P0* (W) linearly decreased from 300 W to 230 W ($R^2 = 0.96$) with the dough hydration level. These results were consistent with the physical observation. However, *TPmax* (s) follows a saturation model reached at 58% of hydration.

Since these two flours were selected for their extreme mixing behaviour, these results show that the models established can describe the dough mixing behaviour of any flours. Therefore, this model can be used to apply the necessary settings of hydration level to reach the expected dough behaviour in real processing.

Process modelling up/down scaling

Poster

Inline visualisation of spray impact pressure distribution via augmented reality: An approach to monitor cleaning processes

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Regular cleaning of food production equipment is essential to ensure food safety. Open plant cleaning is mainly done manually. Spray and foam lances are used by the cleaning staff to distribute the cleaning liquid or foam onto the surfaces to be cleaned. The human factor brings in necessary flexibility, but the reproducibility of the cleaning results depends on the skills of the personnel and is often low. An inline visualization of the cleaning results can help to strengthen the food safety management systems.

The poster shows a virtual cleaning assistant supported by augmented reality (AR). The system consists of three main components: i) spray lance with integrated tracking system for pose and position detection, ii) visualisation device (AR headset, smartphone) for displaying cleaning progress, iii) digital cleaning twin for data acquisition and simulation.

An innovative 3D tracking concept was developed for the tracking spray lance to record the position and orientation of the nozzle in space or in relation to the machine surfaces. 3D stereoscopic sensors with suitable VSLAM algorithms are used. Cleaning parameters such as water pressure are recorded via the CIP base station. The position and cleaning parameters are continuously sent via a remote connection to a server on which a digital 3D-image of the production environment is running. Here, the data is merged and used as input parameters in a quasi-real-time spray-cleaning simulation.

The simulation is based on nozzle data, in particular the impact pressure distribution. These parameters were measured as a function of nozzle distance, nozzle surface angle and pressure. The nozzle data is generated using an automated XYZ-linear table, which scans the full spray pattern.

During the cleaning process, based on the current position of the spray lance an impact pressure distribution of the applied cleaning liquid can be calculated and projected onto the 3D model of the machine to be cleaned. This visualization can be used by suitable AR devices to reflect the cleaning performance back to the cleaning specialist in almost real-time.

This feedback on the cleaning progress enables the cleaning personnel to avoid spray shadows or over-cleaned areas.

Poster

Modeling and Simulation of Smoking and Drying of Protein-based Food Products

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A mathematical model for simulation of simultaneous heat and mass transport was developed to describe the smoking and drying of protein-based food products in an industrial smokehouse. In this model, the governing equations for heat and mass transfer for a solid cuboidal body were numerically solved using a finite element technique. In addition, a kinetic model was coupled to the heat and mass transfer computations to simultaneously predict the development of product surface color in terms of the browning index (BI) during the drying process. This provides predictions of moisture content, temperature, and surface color profiles of the product in a space-time domain during the smoking and drying process as a function of various operating conditions.
Predictions compared well with the experimental values, suggesting that the proposed numerical model can be used with confidence for the simulation of transport phenomena in optimizing the design and operation of smokehouses that minimizes process time while achieving the desired surface color. The study has depicted the significance of establishing optimal and controlled smoking and drying conditions because the effects of the key operational parameters on processing time and the associated changes in product surface color were found. The modeling strategy proposed here can be extended to other food products and different quality indices.

Process modelling up/down scaling

Poster

Hybrid modelling of Ohmic Heating system dynamics by integrating mathematical and physical components in MATLAB (Simscape)

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Food processing industry is a major manufacturing sector that is considered to be largely responsible for energy consumption and greenhouse gas (GHG) emissions. Therefore, alternative technologies to conventional heating methods are being developed for deployment in the food processing industry. Ohmic Heating (OH) is one of the volumetric heating technologies that uses Moderate Electric Field (MEF) processing system for heating food products effectively using electricity only. This can provide a solution to the food and drink industry to improve energy efficiency and decarbonise their food manufacturing processes. Various mathematical ohmic heating models have been developed to investigate and study the effect of numerous parameters on different types of food products over the years. However, not much attention has been paid to physical model-based designs of these Ohmic Heating systems. A model-based design can more accurately reflect the physical characteristics (such as, convectional currents during the flow, product mixing, backflow, etc.) that are challenging to model mathematically. Hence, physical model-based simulations are essential to analyse the impact of processing dynamics in MEF-based Ohmic Heating. In this research, a model in MATLAB using the Simscape toolbox is developed to study the effects of MEF heating technology with respect to various physical conditions of the food product. Furthermore, the model is validated against an established mathematical model and a commercially designed continuous ohmic heater with mean square error value of ±0.4. The validated model can effectively simulate temperature variations with the change in thermophysical properties of the food product. It also allows to evaluate system dynamics in real-time scenarios. Moreover, the developed model is capable of investigating the effects of several significant characteristics on MEF-based Ohmic Heating of food products, such as the electrical conductivity, product temperature, density, flow rate, and magnitude of the applied electric field. Therefore, this simple but effective physical model is an optimal approach that can be used in model-based control system design to improve the performance and energy efficiency of the Ohmic Heating processes.

Process modelling up/down scaling

Poster

Dynamics of cake baking: A coupled multiphase poro-hygro-viscoelastic model

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Research Justification
Cake baking involves complex physics of simultaneous transport and large deformation during which a liquid batter rises and sets into a solid porous structure. Engineering understanding of the cake baking processes is limited, and the process control to obtain desired performance metrics of cakes, such as cake height, weight, porosity, and color are currently based on a trial-and-error approach.

Objective
To provide a first principle-based mechanistic understanding of the cake baking process thus providing a rational basis for optimization and novel developments in products and ovens.

Methods
A coupled multiphase, multicomponent porous media transport model with evaporation, large deformation, and material transformation (phase change from starch gelatinization) is developed for cupcake baking in a conventional oven. The equations are solved numerically to predict the evolution of temperature, moisture, large dimensional change, and color of the cupcake batter during baking. The model is validated against measured temperature, moisture, color, and height of the cake during baking. The novelty of the numerical model is the coupling of the massive change in mechanical and thermophysical properties with multiphase transport and expansion due to pressure as well as moisture loss from shrinkage.

Results
The predicted internal temperatures, moisture loss, deformation, and color formation of the cupcake during baking for different oven settings agreed well with the experiments. The average moisture at the end of the baking cycle was around 30% of dry solid mass, the average deformation was about 100%, and the average browning index was around 30-40. The model showed that the amount of internal evaporation and the onset of starch gelatinization decided the final moisture content, height, and color of the cupcakes. The model also showed that the deformation profile during baking followed the gas pressure profile inside the batter.

Conclusion
The model enables a comprehensive quantitative understanding of the effect of coupled transport and deformation on both the surface and internal physical condition of baked goods for a whole host of complex baking processes, with cupcake baking as an example. As part of computer-aided food engineering, it will greatly enhance the optimization of equipment (oven) and baked product design.

Process modelling up/down scaling

Poster

Mixed-Culture Beer Fermentation: A Data-Driven Approach to Real-Time Multi-Variate System Modelling and Predictive Process Control

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The beer brewing sector has seen rapid and radical changes in recent years. During the previous decade alone, the number of independent breweries in the UK has more than doubled, spurred by the ever-increasing popularity of the craft beer movement. Craft beer is renowned for originality, novel beer styles, and unique flavour characteristics; a notable area of innovation within the craft movement has been the rediscovery and development of beers fermented using mixed-culture inocula. Mixed-culture fermentation is highly advantageous for breweries seeking distinctive flavours and beer characteristics. However, compared to pure monoculture fermentation, mixed-culture fermentation has significantly more biochemical complexity. Therefore, the production of consistent mixed-culture fermented beer, particularly at scale, presents a substantial brewing and engineering challenge. Consequently, there is a growing demand for cost-effective predictive process control and system modelling of mixed-culture beer fermentation processes, improving batch-to-batch product consistency and offering decision support to brewers. Therefore, this paper proposes an empirical, data-driven approach to multi-variate system modelling and real-time predictive process control for mixed-culture fermented beer. Training and testing data were generated using a sensor array monitoring critical fermentation parameters of pure monoculture and mixed-culture co-fermented beers brewed at pilot-scale. These data were used to train and test machine learning and artificial intelligence algorithms, producing an effective system for monitoring and estimating critical system parameters. The system effectively simulates and predicts fermentation behaviour for monoculture fermentations using ale and lager yeasts in addition to co-fermented ale and lager yeast mixed-culture fermentations in real-time. However, while the system proved effective for this application, there is significant scope for future work in this area. Specifically, future work is required to generate training datasets of real-world mixed-culture fermentations, particularly of yeast and lactic acid bacteria co-fermentations.

Process modelling up/down scaling

Poster

A deep-learning enabled approach to building robust and versatile computer-aided design tools

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Simulation-based product/process design tools critically depend on fast and accurate simulations. However, complex food process simulations are generally unwieldy for performing practical “what-if” scenarios for design and optimization, providing a major bottleneck in digital food manufacturing. Using convective drying of fruits as a popular process application, we show an approach to developing robust and user-friendly tools with vastly reduced computing resource needs for safety and quality simulations for a wide range of products and processes. Additionally, the tool includes a fast, efficient, and flexible algorithm for optimization of safety and quality within a wide range of parameter values.

The tool is built upon a complex multiphase and multicomponent porous media-based mechanistic model that shows good agreement with experimental data from a commercial dryer. However, for practical use, the tool needs to produce fast results. To this end, a surrogate of the mechanistic model is built by training a dynamic and memory-retaining neural network on the detailed spatiotemporal solution of temperature and moisture content, which is combined with safety and quality kinetics to predict a variety of safety and quality parameters of practical use. We have also explored two evolutionary optimization algorithms that can handle multi-objective problems with high-dimensional parameter space.

The surrogate model could make predictions in a negligible fraction of the time (4-6 seconds as opposed to ~4 hours) it takes to get the same results from the mechanistic model. Of the 40 test cases, 25% showed a RMSE value of less than 2ºC in temperature and 0.1 in db moisture content, while the median error was 5ºC in temperature and 0.2 in db moisture content when compared to the corresponding solution from the mechanistic model. The optimization algorithms showed remarkably fast convergence when compared to general exploratory methods of optimization.

The versatile digital tool (an app that can be run on a smartphone) with its robustness and quick predictive capability aides in practical product and process design through quick estimation and optimization of safety and quality in a drying process, reducing experimentation, shortening time-to-market, and providing avenues for novel changes that are much desired by industry.

Poster

Computational design and manufacturing of microwave systems for food processing

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Microwave (MW) processing, at 2450 and 915 MHz frequencies, is widely used by the food industry with its high-energy efficiency. Recent concerns on sustainable processing for reduced energy with high-quality products make it attractive while industrial systems still do not achieve a uniform electric field distribution. This results in non-uniform temperature distribution with quality losses. The objective of this study was to present a computational design approach from the lab- to pilot and industrial scale systems.
For this purpose, a mathematical model was first developed to determine the electric field and temperature distribution in a lab-scale system and validated with experimental data for various processing conditions. Then, a pilot-scale continuous system was optimally designed using this model for the optimal location of magnetron size of the cavity, and it was manufactured by IFTECH. Following the second set of validation in this system, industrial scale tunnel systems with various number of magnetrons (9, 18 and 36) were computationally designed.

The experimental model validation studies in lab- and pilot-scale systems were carried out with agar (97% solid) and Tylose samples (75% water content), and the models were validated by using the experimental temperature change data (the RMSE values for both cases were lower than 2 °C). The pilot-scale system was recognized with the optimal electric field and temperature distribution within the cavity. For designing industrial scale systems, a higher number of magnetrons led to significant issues for electric field distribution, and various designs were introduced for different food products (e.g. required design for pasteurization of particulate foods differed from the design for thawing of larger size products). For the same tunnel design, the use of 9 magnetrons was determined to lead to a more uniform electric field distribution with improved efficiency compared to the higher number of magnetrons while the applied frequency was a significant factor.
The significance of computational design for efficient MW system manufacturing was presented, and it was demonstrated that the industrial scale manufacturing and further processing required a significant design and optimization study for sustainable processing.

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Process modelling up/down scaling

Poster

Modelling the extraction kinetics of ?-Carotene and Betalains for solid-liquid extractor design

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Betalains and Beta-carotene are two bioactives which are widely present in human diet. Betalains are potent antioxidants and Beta-carotene is a precursor of vitamin A. Betalains are extracted from beet root, either from raw beetroot or its processing waste, using polar solvents such as aqueous ethanol. Beta-carotene, on the other hand, is extracted from carrots or its processing wastes into non-polar solvents such as hexane and edible oils. Betalains and Beta-carotene are known to be thermolabile, and extraction conditions must be carefully chosen to minimise degradation. A semi-empirical model is developed to characterise the extraction kinetics of: 1) Betalains in aqueous ethanolic solution (10, 20, and 30%) at temperature ranges 55-85 °C, and 2) Beta-carotene in sunflower oil at the temperature range 90-150 °C, which can be employed for designing and optimising solid-liquid extractors for separating these bioactives. The model considers the net rate of change of bioactive concentration in the extract to be a balance between: i) the rate at which the bioactive is released from the solid phase and ii) the rate at which the bioactive decomposes in the extract phase.The main parameters of the models are: C_{si} – representing the mass of extractable bioactive in the solid phase, k_m representing the dynamics of solid phase exhaustion/extraction with respect to Beta-carotene or Betalains, and k representing the first order rate constant for the degradation of bioactives. The model is experimentally validated, and the model parameters are used to design and compare the performance of different types of extraction systems. This study shows that careful selection of the operating variables such as extraction time and temperature can eliminate the need for using process intensification methods which involve the use of expensive devices such as microwave and ultrasound. Experimental data are also presented for the thermal degradation kinetics of both bioactives to help develop robust extraction systems. In general, Betalains were found to be more thermally labile than Beta-carotene. The experimental data and model shows a good fit with lower values of sum squared error (SSE) and root mean square error (RMSE) and higher values of R^2 and Adj. R^2.

Poster

HYPERSPECTRAL IMAGING AND PATTERN RECOGNITION FOR DETECTING ADULTERATION IN GOAT CHEESE SAMPLES

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Hyperspectral imaging (HSI) has become an important asset for food authenticity. Some advantages of the HSI when compared to non-imaging devices are related to the spatial distribution information, which enables a better sampling and can increase the sensitivity, being able to detect adulterants below the levels achieved by conventional measurements[1]. Goat cheese is an important food product of the Mediterranean countries with high market value, and usually prone to adulteration. Adulterations with plant-based fat (e.g. palm oil) or animal fat (e.g. cow)' are common issues encountered by regulatory agencies. The aim of this work is to investigate the ability of HSI and pattern recognition tools to detect adulterations in goat cheese samples for authenticity purposes. Authentic goat cheese samples were adulterated with different percentages of palm oil and cow cheese. The samples were imaged using the hyperspectral camera FX10 from Specim (Oulu, Finland), with 5.5 nm of spectral resolution, spectral sampling/pixel equal to 2.7 nm at the range of 400 to 1000 nm (visible/near infrared). Principal component analysis (PCA) was performed and the scores images from PC1 showed differences from the authentic and adulterated samples. The samples with palm oil are related to the absorption around 930 nm (CH2 bond in fat) while the differences between cow and goat cheese are related to the absorption at 500 nm and 950-1000 nm. Partial least squares regression (PLS) was implemented and compared with multivariate curve resolution – alternating least squares (MCR-ALS) to quantify the adulterants. The MCR-ALS model was able to identify subtle variations of palm oil in the adulterated goat samples, but not in the samples adulterated with cow cheese. The 1 latent variable (LV) PLS model for cow and palm oil adulteration percentage resulted in R2pred of 0.96 and 1.0 and RMSEP of 4.3% and 4.2%, respectively. PLS analysis has given suitable results for the identification of adulterants with higher than 10% of adulteration, showing the potentiality of HSI-VNIR for goat cheese authenticity assessment.
[1] Pasquini, C. (2018). Analytica chimica acta, 1026, 8-36.

Process modelling up/down scaling

Poster

CFD modeling of airflow and temperature distribution in a smokehouse

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An industrial smokehouse is a forced-air convection chamber used to smoke and cook food products. Smoking has been practiced for centuries as a food preservation method. The smoking process consists of three phases: condensation of water on the surface, the adsorption of smoke elements on the surface, and drying the surface. These phases are governed by the heat and mass transfer rate both inside the product and at the interface between the air and the product surface. The heat and mass transfer rate are influenced by the air temperature, relative humidity, inlet vent air velocity, smoke density, and airflow uniformity within the smokehouse.
The typical ventilation system of smokehouses significantly influences airflow and temperature distributions within the chamber. These parameters, in turn, directly impact the product quality attributes and process efficiency. The overall objective of this study was to develop a 3D Computational Fluid Dynamics (CFD) model to study the effect of smokehouse ventilation system configuration on airflow uniformity. The model was validated with experimental results from the prototype smokehouse (3.15 m x 1.69 m x 2.94 m). Results include detailed analysis on the effect of ventilation system configuration on air velocity, air temperature, and average surface heat transfer coefficient and temperature of a meat analog. The CFD model can be used as an effective tool to design and evaluate new vent configurations to improve airflow uniformity in smokehouses.

Poster

Phage attack of lactic acid bacteria: a dynamic predictive model

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Milk acidification is a key step in the cheese-making process. In the industry, bacteriophages can attack lactic acid bacteria (LAB), which are responsible for the conversion of lactose to lactic acid. In consequence, acidification can be reduced or even stopped, leading to a halt in the production and thus severe economic losses for cheese-makers. The goal of this study is to develop a dynamic mechanistic model to predict the dynamics of phage attack.
To build the model, acidification curves, i.e. pH measurements versus time, were generated for 96 different couples of initial LAB concentrations and phage titers.
A dynamic mechanistic model was then constructed and consisted of 6 ordinary differential equations for the state variables: lactose and lactic acid concentration, susceptible, infected, and dead LAB concentration, and phage titer. The model parameters were estimated by minimizing the squared discrepancies between observed data, on the one hand, and their expected values on the other. The model and its optimization were implemented using python.
The acidification data showed that normal acidification takes place when the LAB concentration is high and phage titer is low. When the LAB concentration decreases, the acidification is delayed. With high phage titers, acidification can be delayed, prematurely stopped or not take place at all.
The model was able to predict satisfactorily most of the cases. Parameters were estimated with a reasonable confidence interval. The model simulates time evolution of phage and bacteria concentrations which are not measured routinely.
The model succeeded in predicting most of the phenomena taking place in the experiment. Important parameters and behaviors were deduced from simple and low-cost acidification measurements. The model can be expanded to include different phages and bacteria species, and blends of both to mimic a typical cheese-making environment. The model can be used to raise awareness amongst cheese-makers on the importance of cleaning to avoid economic losses.

Poster

Numerical modelling of deformation and rupture of gas cell walls in bread dough during baking

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Objective:
During bread-making, the gas cells undergo continuous expansion and, consequently, the gas cell walls (GCW) separating them thin from several hundreds to a few µm, until their rupture. It is well accepted that the GCW rupture moment is crucial for a good quality bread. In contrast, the understanding of stress concentration on the GCW scale, and the role played by the starch granules in it, has received little attention. Therefore, the aim of this work was to model this thinning process occurring at small scale, as a preliminary step to multiscale modelling of bread baking, and in complement to other higher-scale modelling tools available in the research team.
Methods:
For the model, a GCW was represented by a single wheat starch granule surrounded by gluten, and the possible rupture points were localized through the analysis of von Mises stress fields under unidirectional extension. This model was fed with Young's moduli values coming from the literature for gluten and from dedicated experiments for starch. Compression-relaxation tests were carried out at different temperatures for different starch types (varying in terms of botanical origin and variety), and two extreme water contents depending on the starch type.
Results:
Simulated stress concentration within the GCW was highly dependent on the characteristics of starch granules, and was the highest close to the edge of the starch granules. Flattening of starch granules was simulated when Young modulus of starch was lower than that of gluten. In such case, stress distributes more uniformly through the GCW thickness, lengthening extension and delaying rupture. Likewise, mechanical tests showed that Young modulus decreased with temperature whatever the starch type. Under the range of water content under study, Young modulus of starch was higher than that of gluten, except for waxy wheat starch.
Conclusions:
This work illustrates an example of modeling at small scale (µm) and highlights the lack of experimental data at these scales but also the need of experimental strategies to be developed to obtain them. This is illustrated here with the mechanical properties of starch; that of gluten and the gluten/starch interface constitute perspectives to this work.

Process modelling up/down scaling

Poster

Bread baking simulations: an attempt to take into account formulation and partial-vacuum baking technology to reduce baking temperature and optimize bread quality

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Bread baking is one of the most energy demanding food processes and bakers have become increasingly concerned with the need of optimization tools to better control raw material fluctuations and reduce baking energy consumption. Although numerical modeling still does not cover all the complexity of the phenomena involved during baking, we think that numerical modeling can help R&D. Modeling makes it possible to approach phenomena that are difficult or impossible to isolate/disentangle experimentally and at lower economic and environmental costs. In response to the lack of literature dealing with the prediction of bread texture from physics-based models [1], this study attempts to use multiphysics simulations of baking as a supporting tool for studying the impact of both process and formulation parameters on overall expansion, bread crumb density and spatial gas fraction heterogeneities.
The numerical simulations were conducted using a finite element model that has previously been experimentally validated on French baguettes. The model takes into account CO_2 yeast's production below 40°C and its desolubilisation from the liquid phase during heating, liquid and water vapor, and air. The dough deformation is governed by both gas production and the evolution of the mechanical properties of dough during baking. Gravity and shrinkage due to water loss as well as gas cell opening and evapo-condensation-diffusion are also considered.
A reference simulation at atmospheric pressure first helped us to deepen the phenomena involved in the aeration or densification of the crumb. Then the study mainly focused on the combination of different yeast gas productions, and modified starch gelatinization/gas cell opening temperatures with baking at lower temperatures than those usually used in conventional baking. These simulations suggested some interesting paths when combined with partial-vacuum baking. A lowering of external pressure of only 5 kPa positively influenced the overall expansion and crumb density was 8% reduced compared to that baked at atmospheric pressure.

[1] Purlis, Emmanuel, Cevoli, Chiara et Fabbri, Angelo, 2021. Modelling Volume Change and Deformation in Food Products/Processes: An Overview. Foods. avril 2021. Vol. 10, n° 4, pp. 778. DOI 10.3390/foods10040778.

Poster

Modelling of heat and mass transfer phenomena during contact heating of food products

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Contrary to thermal convection and radiation heat transfer, and in spite of their importance in some heat treatments such as shallow frying or roasting, contact heat transfer has rarely been studied from a thermal engineering point of view in the case of food products. This is mainly due to the metrological and theoretical difficulties associated with the characterization of transfer phenomena occurring between a solid heating surface and a heated food product whose structure and composition are likely to change drastically during contact heating inducing an important series of phenomena affecting in return the studied heat and mass transfer phenomena: deformation of the heated surface lowering the surface of heated product in contact with the heating surface, release of liquid exudates and rapid evaporation then formation of a crust at the level of the contact with the heating surface. To deal with this, kinetics of product water loss and temperature rise were recorded during contact heating of three different types of food product (potato slices, omelette, pancake batter) in order to examine the influence of the heating power and of the presence or not of an oil layer below the heated product and the heating surface. From these experimental data, a 2D mathematical model based on a moving boiling-front approach was developed and validated. One of the objectives of our study is to propose a mathematical formalism that is sufficiently mechanistic to identify the sequence of transfer phenomena that occur during heating, but generic enough to be applied to the three products chosen for the study and even generalized to other solid or liquid food products. The analysis of the calculated results showed that, the overall heating of the product is limited by: (i) the evaporation of liquid water at the position of the boiling front propagating within the heated product and (ii) the formation, below the boiling front a dried zone which acts as an insulating layer. Realistic values of contact heat transfer resistance were also identified filling gaps in the bibliography on the subject.

Poster

Removal of viscoplastic soiling layers by obliquely impinging water jets

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Objective
Liquid jets are widely used in CIP systems to remove residues from the walls of process vessels. Several systems employ rotating heads with several nozzles which move the jet over the surface, creating a dynamic cleaning pattern. Predicting the performance of these systems requires an accurate description of how the liquid is distributed when it impinges obliquely on the wall, and the associated rate of soil removal.
Methods
Series of experiments were performed to determine the flow distribution generated by 2 mm diameter coherent water jets impinging on vertical PMMA surfaces at different angles. Video analysis was used to estimate the flow rate from the initial location of the hydraulic jump and from the local cleaning rate of Nivea Soft, a viscoplastic emulsion. Both methods allowed the whole azimuthal range to be mapped.
The information combined with the jet cleaning model of Bhagat *et al*. (2017; Food & Bioproducts Processing, **102**, 31) in a Matlab^{TM} simulation of a rotating cleaning nozzle operating at a range of settings to predict its the cleaning effectiveness.
Results
The flow distribution functions obtained using the two methods showed good agreement. The amount of liquid flowing in the principal jet direction was smaller than predicted by the Hasson and Peck (1964; *AIChEJ*, **10**, 752) model. A one-parameter modification of this model gave good agreement with the data.
The observed rate of cleaning fitted the Bhagat et al. model reasonably well. Simulations reproduced the hatched pattern observed in practice for rotating nozzles. The fraction of surface cleaned increased very slowly in the final stage. The model does not include ageing of film drainage effects which would introduce time dependent removal kinetics, and this should be included in future work. The results allow the sustainability and effectiveness of different combinations to be compared.
Conclusions
The distribution of liquid generated from an impinging jet differs slightly from that predicted by geometric models. A good description of the flow function can be provided by a modified model, which, when incorporated in cleaning simulations, allows the performance of rotating nozzle systems to be assessed.

Process modelling up/down scaling

Poster

Critical Analysis of Pork QMRA Focusing on Slaughterhouses: Lessons from the Past and Future Trends

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Foodborne microbial diseases have a significant impact on public health, leading to millions of human illnesses each year worldwide. Pork is one of the most consumed meat in Europe but may also be a major source of pathogens introduced all along the farm-to-fork chain. Several quantitative microbial risk assessment (QMRA) have been developed to assess human health risks associated with pork consumption and to evaluate the efficiency of different risk reduction strategies. The present critical analysis aims to review pork QMRA. An exhaustive search was conducted following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) methodology. It resulted in identification of a collection of 2489 papers including 42 on QMRA, after screening. Among them, a total of 29 studies focused on Salmonella spp. with clear concern on impacts at the slaughterhouse, modeling the spreading of contaminations and growth at critical stages along with potential reductions. Along with strict compliance with good hygiene practices, several potential risk mitigation pathways were highlighted for each slaughterhouse step. The slaughterhouse has a key role to play to ensure food safety of pork-based products but consideration of the whole farm-to-fork chain is necessary to enable better control of bacteria. This review provides an analysis of pork meat QMRA, to facilitate their reuse, and identify gaps to guide future research activities.

Process modelling up/down scaling

Poster

Numerical modeling of heat and mass transfer during cake baking process

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This article deals with the development of a numerical multiphysic model to study heat and mass transfer phenomena as well as the swelling during the baking of a cake contained in mold. The aim of this study is to provide an effective numerical tool, experimentally validated, for a better understanding of mechanisms leading to the desired end product. In this approach, the medium is assumed to be a deformable porous medium containing three phases: solid (dough), liquid (water) and gas. Gas phase includes two species, water and CO2 (released by the leavening agent). Based on the governing equations for heat and mass transport and under few assumptions (homogenous medium, local thermodynamic equilibrium, gas phase assumed to be an ideal gas mixture…), the problem consists in solving a system of five coupled partial derivative equations. The state variables are the temperature, the moisture content, the total gas pressure, the porosity and the displacement. The swelling of dough caused by the increase of total gas pressure is predicted by a viscoelastic model. This thermo-hydro-mechanical model is implemented in finite elements code.
At the same time as numerical approach, experimental tests are carried out on a laboratory oven. In this context, an experimental laboratory set-up was developed in order to continually acquire temperatures, water losses and to correctly apprehend the boundaries conditions. The cake deformation is also tracked by camera. The numerical results are next compared with experimental data and analysed. Various operating conditions are tested to check the robustness of predictions.
Moreover, a sensitivity analysis is performed to understand the impact of material properties and model parameters on the behaviour of cake during baking process.

Process modelling up/down scaling

Poster

Using Moving Particle Simulation approach to investigate mechanical and thermal stress profile in a twin screw extruder

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Current trends in the food industry and research are focused on the development of sustainable and functional foods, such as meat substitutes. Twin screw extruders are frequently used here to mix the raw materials used with water and to functionalize, shape and texture the matrix. The properties of the resulting products are influenced, both, by the mechanical and thermal stress profile in the screw section and the flow conditions in the die section. While the various influencing parameters are known, a fundamental mechanistic understanding of the processes in the extruder is lacking. Accordingly, product and process development in industry is largely based on the trial-and-error principle, which requires a high level of resources and usually offers no solution for complex food systems.

In this work, we address this problem by applying numerical simulation methods that allow a detailed analysis of process conditions. The advantage of this approach is that properties relevant to food systems can be determined, some of which are not measurable in experimental investigations.

We present a Moving Particle Simulation (MPS) model that we set up to examine the flow of a protein-water mixture through a laboratory scale extruder. The MPS model was used to establish a relationship between residence time and degree of filling. By varying the screw configuration under otherwise constant process conditions, a different degree of filling was realized. It was found that the mechanical stress history experienced can be related to the degree of filling in the extruder. In addition, the thermal stress history in the extruder could also be considered using the energy equation.
The results obtained help to build a fundamental mechanical understanding of the processes in the extruder. Furthermore, the data can be used to perform a targeted scale-up.

Food performances, properties, digestibility & functionalities

Oral

Release kinetics and encapsulation efficiency of embedded active ingredients in fat-based matrices using cold extrusion

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Cold extrusion offers great potential as a continuous and gentle encapsulation technique. Due to their melting and crystallization properties, lipids are ideal matrix materials as they can be influenced by extrusion process parameters, such as temperature and shear. This offers the possibility to develop various lipid-based matrix materials with specific release properties, ensuring a delayed release during gastrointestinal digestion. The objective of the present work was a methodical physicochemical characterization of cold extruded fat matrices serving as matrix material for the embedding of 10 % beetroot powder, which was used as model active agent due to its detectability by photometric measurement. The matrices were composed of a high-melting fully hydrogenated rapeseed oil as the base fat and one of four low-melting fats/oil. By performing a semi-dynamic in vitro digestion test, physicochemical characteristics of fat-based matrices influencing release properties and encapsulation efficiency of encapsulated beetroot powder were identified. The results showed that the matrix composition influenced, particle size distribution, melting behavior and microstructural fat distribution. Melting behavior and solid fat content proved to be determinant properties influencing the release behavior – especially, the deviation of solid fat contents in the temperature range from 20.0 °C to 36.5 °C (room and body temperature) during in vitro digestion. Generally, a higher content of low-melting fat led to an increased release of beetroot powder during the intestinal phase of up to 48 %, whereas only 3.3 % on average were released during oral and gastric phase each. Microstructural analysis showed that melting properties are also influenced by the time factor as a temporal delayed release of beetroot powder was determined.

Oral

Cytotoxic evaluation of liposomes/chitosomes using chicken fibroblast cell line

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Liposomes are biocompatible structures that can be applied as versatile carrier systems for unstable ingredients. Especially in the food sector, liposomes are used to encapsulate bioactive compounds, aiming to facilitate their incorporation into the food matrix for animals and human nutrition. This strategy allows the production of functional foods with higher nutrient absorption through the intestine. However, liposomes' major drawback is the encapsulated compound's leakage during storage and digestion. In this way, liposome coverage using biopolymers is recommended to avoid leakage and increase stability in a non-toxic system. In the present work, liposomes were produced by the thin-film method, and chitosan was selected as the coating material for liposomes using two strategies: electrostatic interactions (chitosomes) and ionic gelation by adding sodium tripolyphosphate (TPP-chitosomes) solution drop-wise. The produced particles were characterized through transmission electron microscopy (TEM). Cytotoxicity was assessed in chicken fibroblast cells (CEC-32) treated with particles in four different concentrations (20%, 10%, 5%, 1%) in two-dimensional (MTT assay) and three-dimensional (Alamar blue) structures. TEM images clearly showed that liposomes were composed of a lipid bilayer. The three categories of particles had very similar morphology: elliptical format, with approximately 100 nm medium size. However, the TPP-chitosomes micrograph showed a crosslinked network, possibly formed by TPP-crosslinked chitosan. Such a network could act as a delivery modulator for the compound to be encapsulated in this system. The treatment with particles at concentrations of 5% and 1% didn't decrease the cell viability of bidimensional cells at 24h, 48h, and 72h. In tridimensional cells, particles didn't reduce cell viability. In conclusion, these particles represent a potential system for encapsulating compounds in non-toxic nanosystems.

Food performances, properties, digestibility & functionalities

Oral

Study of the synergy between carnauba wax and fat from palm oil to structure soybean oil

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Consumers are demanding healthier alternatives to ultra-processed food products. Structured vegetal oils with natural additives are promising substitutes to animal, and partially and fully hydrogenated fatty acids, added as an ingredient or absorbed while frying the food products. Aiming to understand the carnauba wax potential as a booster to structure solutions of fat fractioned from palm oil (FPO) in soybean oil (SBO), ternary solutions of vegetal waxes, FPO and SBO were prepared and evaluated carrying out standard methods for organogel analysis. A pyramidal graphic was built with 21 different solutions. Critical concentration, oscillatory rheology, oil binding capacity, polarized light microscopy and x-ray diffraction were the methods applied to analyze the solutions. The critical concentration of carnauba wax in SBO was 4 % (w/w), and of FPO in SBO was 50 % (w/w). Concentrations of carnauba wax as low as 1 % (w/w) were able to promote the structuration of solutions containing FPO (37.5 % w/w) in SBO. Apparent solid state of the solutions was confirmed carrying out oscillatory rheology. The synergy between carnauba wax and the FPO to bind SBO was positive since the addition of carnauba wax, even at low concentrations, improved the oil binding capacity. A similar cluster crystal morphology was observed in solutions of carnauba wax in SBO, FPO in SBO and ternary solutions. The crystal morphology determined by polarized light microscopy and confirmed by x-ray diffraction demonstrated that the size of the crystals reduces with the increase of crystallizable compounds concentration. Ternary solutions of carnauba wax, FPO and soybean oil showed interesting technological properties to substitute saturated and trans-fatty acids. Acknowledgement to FAPESP for the scholarships nº 2021/08305-1 and nº 2020/02734-5 and financial support n° 2020/05254-4

Effect of carnauba wax and glyceryl monostearate ratio on foaming ability and rheological properties of whipped oleogel

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Abstract

Oleofoams represent a useful strategy for replace solid fats in food product containing aerated structure, such as sponge cakes, mousse and whipped creams. Their inclusion allows to design food with a lower energy density and less sensitive to microbial spoilage. The study aimed to assess the feasibility of oleofoams based on carnauba wax and glyceryl monostearate, investigating the effect of their ratio on the resulting oleofoam properties. To this aim a total of nine oleogels were prepared by changing the carnauba wax (CW) and glyceryl monostearate (GMS) ratios from 10:0 to 0:10 (10:0, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8; 0:10). The samples were stored at 8 °C for 12 h before the whipping with a hand-held electric mixer for the optimal whipping time. Dynamic rheological analysis (strain sweep and angular frequency sweep) was performed to explore mechanical properties of both oleogels and oleofoams. The overrun was measured to provide information on the gas hold-up in oleofoams, which were also characterized in terms of texture, colour and physical stability. Both oleogels and oleofoams exhibited a solid like behaviour, with the elastic component (G′) dominating the viscous component (G″), confirming the formation of a fat crystal network during the cooling and whipping process. The G′ of oil foams ranged from $2{\cdot}10^3$ Pa to $1{\cdot}10^4$ Pa, which was lower than that of the oleogel that reached values around $2{\cdot}10^5$ Pa. Rheological moduli of oleofoams were slightly affected by oscillation frequency, as well as for viscoelastic solids. The overrun values ranged from 25% to 50% as a function of CW:GMS ratio and showed a very low resistance to penetration (≈ 1-2 N). Although air incorporation was difficult in higher strong oleogels, once entrapping air bubbles will be more stable. All the samples showed high physical stability during storage, improving waste management and preserving overall quality, which are of outmost importance for food industries, but also cosmetic and pharmaceutical application.

Food performances, properties, digestibility & functionalities

Oral

The effect of spray-drying and freeze-drying on encapsulation efficiency, and oxidative stability of ?-3 rich oil in water nanoemulsion during storage

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Ω-3 polyunsaturated fatty acids (PUFA) intakes rise globally as they confer significant health benefits. Fish oil represents 2% of total fats and oil consumed worldwide since both fish and fish discards are rich in PUFA which can be recovered and used as bioactive ingredients fortifying food products. The efficient valorization of fish side streams by extracted PUFA, can play an important role in the circular economy improving economic and environmental sectors, as 35% of the global food losses and waste arrive from fish by-products. However, PUFA are highly susceptible to oxidation, leading to the formation of volatile products with unpleasant smell and taste. Nanoemulsion-based delivery systems can protect hydrophobic compounds from oxidation and facilitate their incorporation into foods, supplements and pharmaceuticals while release them at an appropriate site within the gastrointestinal tract. In order to overcome the limitations of liquid-base delivery system, this study aims to evaluate spray- or freeze-dried ω-3 nanoemulsion powders in terms of encapsulation efficiency and oxidation stability. Oil-in-water nanoemulsion systems were created using two-step homogenization with 10% wt fish oil rich in ω-3 PUFA and 10% wt whey protein or Tween 80. Fish oil nanoemulsion powders were prepared using spray-drying or freeze-drying with mixtures of maltodextrin (5%-30% wt) with 1% alginic acid or 10% Arabic gum as wall material. The physicochemical characters of nanoemulsions (liquid base, powders) were determined using DLS, FTIR and SEM analysis. Encapsulation yield and lipid oxidation were determined at various storage conditions (20-60?C, 11-55% RH).
Ω-3 rich nanoemulsions with transparent appearance and low droplet size (<200nm) were prepared. Both drying methods are equally capable for producing nanoemulsions powders with satisfactory encapsulation yield, (>85%). The mixture of 20% wt maltodextrin and 10% wt arabic gum resulted in nanoemulsion powders with the highest encapsulation yield (90%) while inhibit oxidation during storage at different temperature and RH%.
Ω-3 nanoemulsion powders with high storage stability are suitable for functional food products protecting PUFA for oxidation while increasing ω-3 intake and bioavailability.

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Oral

Development of a O/W nanoemulsion as a delivering vehicle of lipids of interest for application on bovine embryonic growth.

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The objective of the present study was to develop an O/W nanoemulsion (NE), with drops below 100 nm of diameter, emulsified by lecithin and encapsulating cholesterol and L-alpha phosphatidylcholine. The purpose of this NE is the application during the early stages of bovine embryonic growth, seeking to increase its viability. Firstly, the effects of lecithin concentration, homogenization pressure with a microfluidizer, and O/W ratio on the emulsion stability index (ESI) and mean droplet size were investigated. NE was prepared by the emulsification-evaporation technique. For that, the organic phase was mixed under stirring for 10 min, and then mixed with aqueous phase using an Ultra-Turrax® homogenizer. Subsequently, this coarse emulsion was homogenized with a microfluidizer to reduces its droplets size. And then, the NE was placed in a rotaevaporator for eliminate residual chloroform. The obtained NE was homogeneous, white and opaque with a milky appearance. A central rotational composite design was used to optimize the NE fabrication parameters, which were as follows; pressure (100 MPa), O/W fraction (20/80) and percentage of lecithin (1%). The three optimized formulations (F1, F2 and F3) used in the embryo application showed an ESI between 0.046 and 0.086, which reflects a high stability with a very low incidence of destabilization phenomena such as creaminess or phase separation. The average droplet diameter analyzed by laser diffraction was approximately 70-80 nm, being able to transit across the embryonic zona pellucida with pores of average 90 nm of diameter. Atomic force microscopy images clearly confirm morphology of spherical droplets with an average diameter size of lower than 100 nm. The NE behave as Newtonian fluid with a viscosity of ~2.1x10-3 Pa.s. Embryonic developmental analysis was not affected by the NE and the blastocyst rates were similar between control and NE groups, and the cleavage rate was higher in the embryos treated with the F2 formulation when compared to the control group. As conclusions, the optimized manufacturing parameters allowed the production of a very stable NE, able to be used as a deliver vehicle for lipids with potential application to increase and improve bovine embryonic development.

Food performances, properties, digestibility & functionalities

Oral

On the road to a better understanding of the teamwork of multiple commercial emulsifiers and their consequence for intestinal lipid digestion

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In the past decades, researchers have improved understanding on how emulsifiers affect oil-in-water (O/W) emulsion properties, as well as on the consequences for *in vitro* lipid digestion kinetics (i.e. rate and extent). However, the majority of these studies focused on singular emulsifiers, while commercial products most often contain and require multiple emulsifiers. Therefore, this research aimed to comprehend the influence of a commercial emulsifier combination on O/W emulsion properties and subsequent lipolysis kinetics. The emulsifiers were studied individually, as well as in various combinations by applying different concentrations, and compared to the commercial combination itself. The influence of emulsifiers on the dynamic interfacial tension, to estimate their affinity for the interface, and the microstructure of resulting O/W emulsions were evaluated. Afterwards, emulsions were subjected to *in vitro* digestion during which its microstructure and lipolysis kinetics were assessed. Significant differences were observed in terms of interfacial tension, microstructure, and lipolysis kinetics between different preparations. Monoolein was unable to substantially reduce the interfacial tension (>18 mN/m). However, the addition of the synthetic emulsifier or lysolecithin to monoolein resulted in a substantial reduction of the interfacial tension (<14 mN/m). Furthermore, emulsions containing solely monoolein were unstable during digestion, resulting in a significantly lower initial rate and extent of digestion (2.32 min^{-1}, 37.98 %) in contrast to emulsions containing solely lysolecithin or the synthetic emulsifier (5.43 and 7.02 min^{-1}, 58.60 and 68.42 %, respectively). However, addition of more than 50 % of the latter two improved rate and extent of lipolysis to maximally 6.32 min^{-1} and 61.59 %, which was linked to increased emulsion stability. Lastly, dynamic interfacial tension and lipolysis results led to the hypothesis that mainly the synthetic emulsifier and lysolecithin resided at the interface, thereby mainly influencing emulsion stability and lipolysis. Overall, this study showed that different mixes of commercial emulsifiers strongly impact lipid digestion kinetics and small adjustments in such mixes can substantially influence lipolysis kinetics. Aforementioned understandings can be applied to optimize and design emulsions to obtain targeted lipolysis kinetics.

Food performances, properties, digestibility & functionalities

Oral

Influence of oils on plant-based meat analogues: Assessing extrudate's mechanical properties to ensure quality and consumer acceptance

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Whilst the global demand for plant-based meat alternatives continues to grow rapidly, many consumers still lack diversity in marketed products, especially in terms of meat types and variety of protein sources. To meet consumers' demands, new products need to be developed that mimic taste, aroma and texture of meat as authentically as possible. However, various consumer surveys reveal that available products often do not meet consumers' expectations regarding several factors incl. texture, juiciness, and mouthfeel.

An important product feature for achieving a similar product to meat is the fibrous, anisotropic structure, which resembles the product texture of muscle meat. Additionally, to improve the texture and taste of extrudates, oils and fats are usually added to the formulation. Whilst increasing the juiciness perception of the extrudates, oil and fats can also disrupt the fibre formation and act as plasticizers. The degree of interference depends on the interactions between oil/fat and proteins and the protein's emulsifying properties. However, mechanisms involved in structure formation, oil stabilization, and interaction amongst ingredients are not fully understood and are individual for every protein-oil combination. For this reason, this contribution addresses the application of a mechanical, rheological and tribological characterization as solution approach to gain insights into formulation and process parameters, facilitate product innovations and assure an objective evaluation of the resulting product.

The effect of oil on the textural properties of the meat substitutes in terms of customer acceptance were investigated by different techniques. Results show, how parameters such as oil concentration, protein source, and extruder die temperature define the fibre formation. The influence of these parameters on product structure were evaluated using electron microscopy and image analysis. To assess mouthfeel, rheological measurements and texture analysis were performed and compared to meat. This was evaluated using an electron microscope and image analysis. For the assessment of mouthfeel, rheological and tribological measurements and texture analysis tests were performed using a Thermo Scientific HAAKE Rheometer. Results show how these measured data can be related to product structure and used as quantitative measure to compare meat analogs' product properties.

Food performances, properties, digestibility & functionalities

Oral

Comparison of potato protein aggregates obtained by high pressure and heat treatment for potential use as nano-vehicles for hydrophobic bioactive molecules

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The potato starch industry in the European Union alone generates close to 6 million tons of potato fruit juice (PFJ), a highly polluting waste product that is only marginally profitable as fertilizer or animal feed. PFJ contains up to 2% of crude proteins that are essentially wasted nutrients, and though their extraction and isolation have been exhaustively studied, their properties and applications in the food industry remain insufficiently documented. Patatin is a globular protein that makes up 35 to 40% of the total soluble proteins found in potatoes, and has successfully been extracted from PFJ in its quasi-native form and commercialized as a nutritious isolate with a high degree of purity and numerous associated functionalities like gelling, emulsifying and foaming properties. The aim of this work is twofold: (1) to study and compare the aggregation pathways of a patatin-rich isolate via two processes: heat treatment and high hydrostatic pressure and (2) to characterize the obtained aggregates from a physico-chemical and functional point of view in order to select promising structures for the encapsulation of a bioactive molecule. For that, patatin dispersions (1 and 4% w/w) at pH 6 and 7 were subjected to varying temperatures (45, 50, 55°C) or pressure levels (400,600 MPa) for time intervals going from 30 minutes up to 48 hours. The characteristics of the formed assemblies were studied at the micro, meso and macroscopic scales using dynamic light scattering, differential scanning calorimetry, dynamic rheology, fluorescence spectroscopy (in-situ, under high pressure), circular dichroism, size exclusion chromatography, and electrophoresis. The results indicated the pH dependency of the aggregation kinetics and the final sizes of the structures formed for each process, with aggregates twice as large at pH closer to the isoelectric point. At moderate temperatures, micrometric aggregates were obtained within minutes, while high pressure generated smaller aggregates after much longer treatment durations. Insights on protein denaturation, unfolding, protein-protein and protein-bioactive molecule interactions were also acquired. This work shows that the functionality of this plant-based protein can be improved and that this by-product can be valorized as a nano-vector for hydrophobic bioactive molecules in the field of functional ingredients.

Food performances, properties, digestibility & functionalities

Oral

Extruded fava bean ingredients for dairy product application

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There is a growing demand from food sector for highly functional pulses-based ingredients. The functional and nutritional properties of pulses may be improved by processing using extrusion in order to create a wide variety of end-use properties. High protein content (32.5%) and well-balanced amino-acid composition make fava bean (FB) suitable for novel food ingredients. In this context, our objectives are to tailor functional and nutritional properties of FB ingredients using extrusion, and to elaborate innovative yoghurts analogs enriched with extruded FB ingredients. For this purpose, fava bean flour (FBF), starch concentrate (FBS) and protein concentrate (FBP) were processed by twin-screw extrusion for a large interval of specific mechanical energy (SME=100-3000kJ/kg). The pasting properties of extruded ingredients were evaluated by their viscoamylograms, and their emulsifying properties were assessed through oil-to-water emulsion droplet size. The protein digestibility was evaluated using a standardized in vitro static protocol (INFOGEST). Results showed that FBF and FBS ingredients extruded at a low SME presented the highest hot (500-700 mPa.s, respectively) and cold (1600-2000 mPa.s, respectively) paste viscosities, likely due to limited starch degradation. FBF and FBP display the lowest emulsion droplets size (13-40 µm respectively, vs ~100 µm for FBS) due to their high protein content (33-68%, respectively), which makes them suitable as surfactants. Smaller the size of emulsion droplets, better the emulsifying properties. Extrusion increased the protein hydrolysis degree of ingredients during digestion, likely because of the inactivation of anti-nutritional factors, like trypsin inhibitors. Owing to its promising functional properties, the extruded FBF was selected to make yoghurts analogs. The FBF was blended with different proportions of classical yoghurt ingredients (cow-based skim milk and cream). A concentration of dairy (33 g/L) and fava (17 g/L) proteins of 50 g/L in yoghurt was found to be optimum for obtaining desirable texture: firm and adhesive (penetrometry), smooth and absence of grating sensation (sensory perception). The presence of a sufficient amount of starch (23 g/L), brought by FBF, is essential for the gel formation, before phase separation. These results highlight the technological and nutritional potentials of extruded FB ingredients. Digestibility properties of novel yoghurts will be investigated further.

Food performances, properties, digestibility & functionalities

Oral

Fabrication and characterization of starch-based structural materials for edible robotic applications

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Edible robots are an upcoming generation of robots, which could diversify the applications of robots in society. An edible drone could provide necessary water and food to people who have limited access to resources during emergencies. Compared to traditional drones, the mass ratio between the edible and non-edible components of an edible drone is much higher, which could potentially reduce the cost and increase the efficiency of rescuing missions.

Compared to other engineering materials, such as plastics and metals, food materials often have higher density and lower mechanical strength. Thus, fabricating structural robotic components using food materials is challenging. Previous research has proposed the usage of puffed rice cookies to fabricate edible airfoils. These airfoils were made by laser cutting the cookies into pieces and gluing them together with edible glue into a fixed shape. This way of manufacturing edible airfoils is inflexible, resourceful and inefficient. Therefore, the aim of the current work is to investigate the effects of different additives and processing methods on the mechanical properties of starch-based structural materials. Starch is chosen because it is abundant, easy to process and rich in nutrition. We hypothesized that the mechanical properties of starch-based structural materials can be modified with different processing methods and additives.

In this work, we proposed a more scalable and controllable processing method to fabricate light-weight yet strong starch-based structural components, which consists of molding and freeze drying steps. Our results showed the Young's modulus of samples increased when edible fibers were added to the formulation, and the apparent density significantly decreased because of the pores generated by freeze-drying. We systematically investigated the influence of formulation designs using different additives (e.g. cellulose, glycerol), and were able to fabricate light-weight starch-based structural materials with a wide range of mechanical properties (i.e. from flexible to rigid). This work contributes to the development of fully biodegradable and edible robotic components with starch-based materials (e.g. for the purpose of fabricating an unpowered glider) and will bring the prospect of using food materials in other fields.

Food performances, properties, digestibility & functionalities

Oral

Gaps and recent advances in our understanding of anthocyanins stability during processing and shelf life: potential implications to processed products

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Objective
While numerous studies focus on identifying polyphenolic compounds, less attention was given to understanding their non-enzymatic degradation as a function of their chemical structure, with a common generalized perception of low stability and decreased antioxidant capacity upon oxidation. We aimed to provide a more comprehensive understanding by studying the most unstable group of polyphenols, anthocyanins, in simple and complex model systems. Furthermore, in addition to the degradation kinetics, we also monitored the in-vitro antioxidant capacity (TAC) to question the perception of a significant decrease in antioxidant capacity by degradation as a major anthocyanin (bio)functionality.
Methods
A set of 6 single-component anthocyanins differing in their structural features, such as the number and location of the OH-group and the presence of a conjugated sugar, and 3 multi-component anthocyanin-rich extracts as simple and complex model systems, respectively, were studied. Their degradation rate was studied using LC-MS after applying different temperatures and pressures (at pressure-stable buffers). Furthermore, the kinetics of the change in TAC was studied using FRAP and ORAC, and for some, the degradation products were identified and quantified.
Results
We have identified a higher than expected stability of anthocyanins containing a saccharide group in purified conditions, partially related to anthocyanins-polyphenols interactions such as co-pigmentation. Confirming the literature, significant structure-dependent variation was noted, with delphinidins showing significantly lower stability than pelargonidins and cyanidins. However, we also observed and quantified a significant instability of the aglycones (both chemical and physical) with a complete loss of the original cyanidin after 30 min. Interestingly, despite the structure-dependent differences in stability of the glycosides, the activation energy and activation volume were structure-independent (70.4±2.0 KJ/mol and 17.7±3.0 cm3/mol, at pH 7, respectively). Furthermore, despite the degradation, the TAC decreases only mildly, and for ORAC in a purified system does not decrease at all, as was studied for cyanidin-glycoside, showing that the degradation products can, in some cases, have even a higher TAC than the original compound.
Conclusion
Non-enzymatic degradation changes the composition of anthocyanin-rich products, yet the impact of temperature and pressure are structure independent, and more importantly, the suggested loss of antioxidant activity is mostly mild.

Oral

Passion fruit ice cream enriched with nanoencapsulated lutein: antioxidant activity and bioaccessibility of the carotenoid

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Lutein is an important bioactive due to its potent antioxidant activity, as well as to the possibility of its used as a natural dye. However, this xanthophyll is sensitive, susceptible to oxidation by external factors such as heat, low pH and exposure to light. Microencapsulation is an alternative to reduce and prevent such degradation processes, and among the most used methods for the protection of hydrophobic bioactives such as lutein is the emulsification. The objective of this work was to evaluate the antioxidant activity of passion fruit flavor ice creams incorporated with nanoencapsulated lutein, as well as the bioaccessibility of carotenoid. Nanoemulsion was produced by high pressure homogenization, using medium chain triglycerides as the oil phase and phospholipids as surfactants, containing 1 g of lutein/100 g emulsion. Three ice cream formulations were produced (one control with a commercial mixture of passion fruit flavor and color, and two with 0.2% lutein nanoemulsion and 50% sugar reduction, one with 0.5% citric acid). The antioxidant capacity of ice cream was evaluated during 180 days of storage by FRAP methods, capture of ABTS radical and amount of total phenolics. In vitro digestion was performed according to the INFOGEST 2.0 method, modified with parameters for senior (>65 yo) adults. The results for FRAP and ABTS differed from the control for ice cream incorporating lutein, which presented higher antioxidant activities, and for phenolics also showed higher values than the control. Also, ice creams containing lutein-loaded nanoemulsion showed lower degradation of phenolic compounds after 180 days of storage. In vitro digestion data for ice creams enriched with lutein indicated that a significant amount of xanthophyll was still present - approximately 65% lutein at the end of the gastric phase, and 33% at the end of the intestinal phase. Compared to the initial amount of lutein in ice cream, 1/3 of the initial lutein was bioaccessible after the intestinal phase. Therefore, in addition to the possibility of producing an ice cream with natural coloring and antioxidant activity, there was a significant amount of lutein in the bioaccessible form after digestion.

Food performances, properties, digestibility & functionalities

Oral

Impact of pH and temperature on a-galactosides diffusion and degradation during steeping and cooking processes of chickpea, lentils, and beans

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Consumption of pulses becomes more and more important in the context of the climate change due to their low negative environmental impact. Their consumption is however often limited due to presence of α-galactosides, which are responsible to cause digestive discomfort. It is thus of particular interest to reduce the α-galactosides during the preparation treatment (steeping and/or cooking processes) of pulses. The kinetics of diffusion and/or degradation of α-galactosides under different preparation conditions (pH, temperature, and time) of chickpea, lentils, and beans were investigated. It has been observed that even a small pH range variation (between 4 and 6.5), has a great impact on both degradation and diffusion of α-galactosides in the studied pulses. As expected, the diffusion increased with temperature while the enzymatic degradation had an optimum at intermediate temperature, thus leading to a maximum loss of α-galactosides at 60°C for few hours (1-3 hours). Quite rapid steeping treatments (1-3 hours), at intermediate pH and temperature, can thus be proposed for dramatically decreasing α-galactosides contents of pulses (chickpea, lentils and beans) before final cooking.

Food performances, properties, digestibility & functionalities

Oral

Physical pre-treatments of pigeon pea seeds: impact on the conformation and functionality of proteins extracted by aqueous fractionation

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Pigeon pea (*Cajanus cajan*) is a pulse crop native to countries in South America, Africa and Asia. Its high protein content (18-28%) makes it a high potential source for the development of new food ingredients. Seed pre-treatments, such as soaking and boiling, have been shown to be effective at reducing anti-nutritional compounds and improving pigeon pea proteins' digestibility. However, the effects of these pre-treatments on the protein functionality still need to be investigated. The aim of this study was to evaluate the influence of seed soaking and boiling pre-treatments on the protein conformation and functionality in pigeon pea protein concentrates. Three treatments were performed: control (without pre-treatment), soaking in water for 24 h, and soaking for 24 h + boiling for 30 min. After pre-treatments, the seeds were dried at 60 °C, milled, and the flour was dispersed in water. The pH was adjusted to 12.0 and the solution was centrifuged. The supernatant was collected, adjusted to pH 4.0, and centrifuged again. The resulting pellet was collected, redispersed in distilled water and freeze-dried. The composition of protein concentrates showed average values of proteins, carbohydrates, lipids, ash, and moisture of 77, 12, 0.5, 6.7, and 4 wt.%, respectively. To evaluate the effect of pre-treatments on protein composition and conformation, sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE), fluorescence spectroscopy, and Fourier-transform infrared spectroscopy (FTIR) were used. Two bands were identified in the SDS-PAGE, one between 37-50 kDa and the other between 50-75 kDa, probably related to the globulin fraction. The fluorescence emission peak of the proteins for the sample that was subjected to boiling showed a slight shift compared to the other samples. This may indicate partial unfolding of the protein structure. Deconvolution of the amide I region in the FTIR spectrum showed that the boiling treatment caused a decrease in β-sheet and α-helix structures and an increase in disordered structures, such as random coils. Only soaking did not affect the protein conformation, whereas the soaking + boiling treatment resulted in partial denaturation of the proteins and impacted their functionality, especially for the emulsifying, foaming, and gelation properties.

Food performances, properties, digestibility & functionalities

Oral

Effect of germination time on properties, flavour attributes and in vitro starch digestibility of green Altamura lentils

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Germination of lentils (Lens culinaris Medik.) is one of the most common and effective treatment to improve the functional and nutritional properties and expand its usage as an affordable plant-based protein in other food applications. Green Altamura Lentils are quite rich in components essential for good human health such as carbohydrates, proteins, dietary fibres, minerals, vitamins (mainly vitamin B3/niacin) and phenolic compounds.
In this work, the effect of the two germination time -0 (C), 24 (G), 48 (H) hours-on some physico -chemical, functional, aromatic and nutritional features of lentils flour samples have been studied.
Lentil flour samples (CF, GF and HF) were achieved by grinding both the whole green seeds (C) and the germinated seeds (G and H), respectively and then sifted to obtain a particle size < 300 μm.
Germinated samples -GF (24 h), HF (48 h)- showed some differences on results of chemical and bioactive properties of CF(control).
The total starch, amylose content and total phenolic amounts of GF and HF decreased compared to the control sample, while their protein content increased ($p< 0.05$). Flavour attributes were significantly influenced by the germination times. Overall, a total of 14 (CF) and 17 (GF and HF) aromatic compounds were identified.
Germination time affected flour properties, leading to a significant increase in techno-functional properties such as water absorption (WHC), oil absorption (OHC) capacities and swelling index (SI). CF had the smallest WHC (1.65 g /g) and OHC (1.39 g /g). The SI of all samples showed similar behaviors, but GF and HF had the highest SI values at all temperatures (60- 90°C). Germination also had a significant impact on the in vitro starch digestibility of samples. In particular, the different starch fractions (RDS, SDS) and glycemic index values of germinated lentils were found to be lower when compared to the results of control (CF). Technological characteristics of CF, GF and HF doughs were studied by using a Brabender farinograph. Germination strongly influenced all farinographic properties of doughs except of dough development time and elasticity.
In conclusion, germination time could be a key factor for modulating some crucial lentil flour properties.

Food performances, properties, digestibility & functionalities

Oral

Understanding and optimization of rapid and small-scale germination process on the nutritional quality of lentil and cowpea

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Seed germination and seedling growth are traditional practices and an emerging trend in the food industry and consumer demand, as it is considered to be an effective process for improving the nutritional quality and functionality of cereals and pulses. Excepted for barley malting and for fresh seedlings production, germination process is rarely conducted at an industrial scale due to the difficulty to set optimum conditions for producing germinated seeds and seedlings. This project aims to implement a rapid (with lower health risk), small-scale germination process on lentil and cowpea seeds and to analyze the process and germinated products by a multidisciplinary approach. Using a multivariate experimental design, this study considered different germination conditions (temperature, light, and water content) and different germination duration (0h, 3h or 5h, 12h, and 24h) for lentil and cowpea. The germination process was created at small-scale with a temperature-humidity chamber integrating a misting system controlled by a software through the weighing of seeds. This process allows to control the water supply and thus the water content in the seed during the germination process. The nutritional changes for B9 and B1 vitamins, and the antinutritional modifications for α-galactosides and phytate were quantitatively analyzed under the different germination conditions of the experimental design. In addition, immunohistochemistry techniques were used to localize the vitamins B9 and B1, and phytate in lentil during germination. The kinetic of increase in vitamin B9 and B1 and of decrease in antinutritional factors during germination, combined with the localization of these metabolites allows providing transformation path to produce new food products and ingredients rich in B vitamins and poor in antinutrient compounds. The low-tech germination process created can be implemented by any food industry worldwide, as it is simple and not expensive. This opens the opportunity for new ways of processing pulse and can encourage the development of plant-based food, that can be a meat substitute, produce gluten-free products and enhance the food nutrient content.

Food performances, properties, digestibility & functionalities

Oral

Understanding the physicochemical processes involved in cooking legumes to drive water transfer

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The cooking quality of pulses depends essentially on water transfers; they are thermally thin objects. These water transfers are driven by multiple thermal events related to starch (gelatinization, melting) and proteins (denaturations). The objective of this study was to understand the physicochemical processes involved in the cooking of legumes in order to propose technological ways of innovation (facilitating their preparation mode, ready to use...). This study identified, at steady state, the phase changes of starch and protein macronutrients of legumes (lentil, chickpea, bean), using differential scanning calorimetry (DSC) for the separation of thermal events (starch/protein). Modeling by de-summarization of DSC peaks and representation of binary water/starch and water/protein phase diagrams was developed. The combination of these two phase diagrams has made it possible, by adjustment, to represent the behaviour of the ternary water/starch/protein system and to propose a distribution of water between starch/proteins. For example, for chickpeas and beans, the amount of water attributed to the starch increases from less than 10% of the total water to about 35-45% at the end of cooking. The results of this work were able to model the water/starch/protein equilibrium states and will facilitate the representation of dynamic water transfer model in legumes during pre-soaking and cooking.

Oral

Assessing changes in lentils texture during hydrothermal treatment.

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The changes of lentils texture during cooking obey different mechanisms, increase of water content in the seed, starch melting, cell-walls disrupting, the complexity of which is increased by the heterogeneity of the seeds, their genetic and environmental diversity. The aim of this work is to develop a method for measuring texture in order to tackle these mechanisms, by testing different lentil batches.
Three lentils batches, with different canning behaviors (A= conform, B, C = non conform, nc) were provided by Cofigeo (F12-Capdenac). Their compositions, especially in cell wall polysaccharides (CWP), was determined by chromatography and spectrophotometry. Hydration kinetics were determined by soaking at 25 and 95°C and fitted by Peleg's model. Cooking time distribution was measured using a specific device recently developed in our laboratory, inspired from Mattson cooker.
Cooking time distributions, fitted by a Gompertz model, showed that both nc batches (B, C) display shorter characteristic cooking time (tc < 10mn) than conform batch (A) (tc >10mn). Moreover, hydration kinetics showed that, at 95°C, the water content MC (dry basis) =1.3 was reached after 25mn, 15 and 12 mn for A, B and C, respectively. These differences may be attributed to the larger content of A in CWP (14%db) than of B and C (8.2 and 11.5 resp.), since CWP are supposed to act as water barriers.
Texture was assessed by compression test using disk (ø10 mm) applied to one lentil, the most repeatable from the systems tested. From the linear part of the stress/strain curve, apparent modulus Ea value was derived. Surprisingly, for the same MC value (=1.3) and for the three batches, Ea values of cooked lentils at 95°C (2.7 to 4 MPa) were about twice larger than those of the lentils soaked at 25°C (Ea =1.7 to 2 MPa). This result might be explained by two mechanisms: first, the strengthening effect of starch swelling at large temperature, and second, the hydrolysis of CWP by endogenous enzymes that were (re-)activated at low temperature (25°C). Whatever the mechanism, the implementation of biochemical and physical methods allowed us to explain the difference of behaviors of lentils during industrial processing.

Food performances, properties, digestibility & functionalities

Oral

Emerging technologies to enhance starch performance: structure-process-properties relationships and food applications

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Starch is a natural and biodegradable ingredient with large application in many industries, such as food, feed, chemical, petrochemical, paper, textile, pharmaceutical, among others. However, although the industrial demand is vast, the available starch sources are limited, in special considering commercial ones. Consequently, modification strategies are needed to fill this gap. This presentation will discuss emerging technologies to enhance starch performance, with focus on food applications. Firstly, some promising emerging technologies (ozone, ultrasound, pulsed electric field and dry heating treatment) will be presented. Then, the starch processing through that technologies will be discussed, regarding structural modifications (morphology and crystallinity of granules; molecular size distribution and the presence of functional groups) and the impact on starch properties (in special interaction with water and gel formation, including the effect of temperature). Finally, possible applications will be detailed, using as case study the dough expansion (gluten free dough), 3D printing (as a strategy to obtain food for special needs) and bio-based plastics (biodegradable and bio-sourced).

Food performances, properties, digestibility & functionalities

Oral

Study of sorghum grain pretreatments and milling for new functional flours and semolina

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Sorghum (Sorghum bicolor, L) is the 5th most cultivated cereal in the world for its grain. Sorghum is gluten-free and has interesting nutritional properties. In Europe, its cultivation is increasing rapidly, and has benefited from EU funds for its promotion throughout the continent in recent years [1]. Sorghum can provide farmers with diversification and an agronomic response to global warming due to its high photosynthetic and drought tolerance, its reduced and fertilizer requirements, and its resistance to pests [2]. With these agro-environmental qualities, sorghum grain could become an important component of global food security. The milling process is used to transform cereals, by combining different unitary milling operations and sorting of particles according to their size or aerodynamic properties. While this process has been widely optimized for wheat in order to separate the starchy albumen with low contamination of peripheral tissues and germ and produce flour or semolina in the case of durum wheat [3], this milling process has been scarcely studied for sorghum. The main challenge for sorghum is the location of the germ within the grain [4] that affects negatively the stability of flour. The aim of this study is to investigate the influence of pre-treatments (hydric, mechanical dehulling) to remove the peripheral envelopes; the different milling steps and settings associated with different granulometries to diversify the end products usages (semolina and flour). An experimental design was conducted considering these factors to optimize the extraction yield of flour/semolina and the quality of end product. Specific conditions combing pretreatments and milling conditions were identified to produce high extraction yields of semolina and flour. These conditions were tested for hard (white) and soft (red) sorghum varieties to better rely the impact of intrinsic physical and biochemical properties of grain on extraction yield, granulometry and functionality of end products. A focus was then made on germ distribution in the flour and its impact through accelerated aging experiments in controlled temperatures. Biochemical and spectroscopic (FTIR) analyses were used to better assess these changes. A link with the second transformation will be highlighted through some tests in bread and pasta production.

Food performances, properties, digestibility & functionalities

Oral

Anticipating dough behavior in baking industry by tackling gluten network structure

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Understanding the mechanical behavior of the wheat flour dough is a crucial step for the baking industry, not only to optimize end product quality, but also to save time and cost by producing a processable dough. Dough behavior is determined by its rheological properties, which are obtained at mixing, the first step of the process. Thus, the objective of this work is to use mixing power curve P(t) to assess the dough processability in the production line. In this purpose, we have analyzed dough structure and rheological behavior for different mixing conditions.

Four commercial wheat flours were selected according to their distinct mixing behavior, according to P(t). Doughs were then prepared in the Farinograph, at different kneading times (3, 9, 12 min) and at different hydration levels (50%, optimal value determined in the Farinograph, and 66% by weight of flour). The thermo-viscoelastic behavior of the dough at small deformation was determined by dynamic thermomechanical analysis (DMA) and the bi-extensional properties (at large deformation) by lubricated uniaxial compression (LSF).

DMA results are followed by the ratio E'max/E'min, where the variations of the storage module between 55 and 70°C mainly reflect the gluten cross-linking: the higher the ratio, the less the network is developed after the mixing step. At constant deformation eb, the bi-extensional viscosity of doughs follows a power law, for which the consistency index K decreases exponentially with the dough hydration (R^2 = 0.80) from 47 to 10 kPa.sn (eb =1), for all flours, whereas, at constant hydration, the variation of K during mixing is related to the flour tolerance during mixing. Therefore, dough consistency (K) values also reflect gluten network structuring.

These interpretations are supported by results from imaging method (TD-NMR) which show that four dough hydration states exist which correspond to different structuring gluten network, and specific interval of K values. In line, images obtained by confocal scanning laser microscopy confirm the relations between hydration states and gluten network structuring.

So, once integrated, these results will allow predicting the gluten network structuring from the mixing curve P(t) and help implement the necessary on-line settings for bakery production.

Food performances, properties, digestibility & functionalities

Oral

Bringing the concept of healthy to flatbreads through vegetables

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INTRODUCTION: Flatbreads are worldwide one of the oldest-consumed bread. Traditionally, it is prepared from a flattened dough made of flour, water, yeast, and salt, which could be leavened or not, and subjected to a very short baking. Nowadays, the food trend for innovation through novel ingredients has also reached flatbreads (FB). The healthy pattern of vegetables is well-known, owing their high content in bioactive compounds (fiber, minerals, and phenolics). However, scarce information is available about their use as food ingredients for improving the nutritional profile of traditional foods. OBJECTIVE: The aim of this study was to develop innovative and healthy flatbreads exploring the inclusion of different vegetables. Vegetable powders from different sources were screened as bakery ingredients for making gluten FB (single and double layer). METHODS: Vegetable powders evaluated were from fatty fruits (black and green olives), citric fruits (lemons and orange peel), berry fruits (tomato), roots (beetroot and carrot), bulbs (onion), inflorescence (artichoke), green leaves (spinach and chard) and cabbages (kale and pak choi). Proximate composition of the powders was determined. The basic recipe consisted of wheat flour type 85 (100%), water (52.5%), salt (1.5%), dry yeast (1%) and vegetable powder (2%). Fresh flatbreads were evaluated regarding color, texture and sensory properties. RESULTS: There were statistically significant differences in the physicochemical properties (ash, fat, nitrogen content, color, and particle size) of powders. Powders from green leaves and cabbages contained higher amount of minerals (11.88-22.70%), proteins (4.02-5.23%), and insoluble dietary fiber. Flatbreads showed differences according to the vegetable powder added, particularly in their appearance. Regarding texture of double layer FB, leaves and artichoke powders increased the extensibility, and particularly spinach significantly increased the tear force. Conversely, those powders increased the hardness of single layer FB, which was only reduced with tomato powder. CONCLUSIONS: Vegetable powders could offer an alternative for innovation in bakery. They could be used as natural and healthy ingredients, modifying flavor, texture, or the nutritional profile of gluten flatbreads.

Oral

Innovative and emerging processing in bakery, patisserie and chocolate ingredients industry – a leverage towards more sustainable and healthy food solutions

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Innovative and emerging processing technologies in food gain attention steeply as a result of consumer-driven demand leading to diet diversity and complexity. Market trends towards more plant-based diets, interest for pro- and postbiotics (gut health), expectations towards environmental friendly food production, ultimate convenience and creation of new types of textures and taste experiences are stretching the food ecosystem into new research domains. Over recent years, the impact of innovative processing technologies, often developed for applications outside the domain of food, has risen and brings multiple advantages.
Within the bakery, patisserie and chocolate ingredients value chain, nowadays incremental innovations are hardly driven by ingredient choices only. An innovative and smart conversion of ingredients or intermediates, upstream or downstream the formulation process, turned out to have major untapped potential for new innovations hitting the market. This scope is stretching very wide – new delivery format creation, the development of mild texturing and pasteurization technologies, the integration of new emulsification technologies, etc. A concrete industry example, by means of Puratos Cubease® bakery improver format, will be presented, bottom-up, how (re)formulation combined with novel processing technologies can structurally create value in terms of customer convenience, customer experience and reduced environmental impact in a B2B food production environment. Thereby, the selection and role of a well-defined ecosystem, cross-value chain is key to achieve success.
This presentation and examples highlighted invites key technology players, universities and start-ups present to collaborate with an open mindset with food industry, reflecting not only on technological and product property benefits but as well on economic viability and financing systems to integrate novel processing technologies in the food value chain successfully.

Oral

Effect of egg yolk components on the glassy state of sugar and gluten formation in cookies

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This study, focusing on egg yolk plasma and egg yolk granules, investigated the effects of egg yolk components on the glassy state of sugar in cookies and the formation of gluten in the dough, and their effects on the *kuchidoke* of cookies. *Kuchidoke* refers to the “melt-in-the-mouth” sensation. Four kinds of cookie were prepared using different mass ratios of egg yolk to egg white (0.2 to 3.1) then their *kuchidoke* scores were determined by sensory evaluation. The amount of sugar in the glassy state was estimated from the heat difference before and after the glass transition of sugar measured by differential scanning calorimetry (DSC). Cookies to which egg yolk plasma and egg yolk granules had been added instead of whole eggs were also prepared to investigate their influences on gluten formation, and then their *kuchidoke* scores were also evaluated. Dough sections were immunostained for gliadin in raw wheat then observed under a fluorescence microscope. The fragment lengths of the gluten were calculated by image processing.

The results of sensory evaluation tests showed that the cookie contained the larger amount of egg yolk in cookie was rated higher for *kuchidoke* score. It was also confirmed that the cookies with egg yolk plasma added had better *kuchidoke* than those with egg yolk granules. No correlation was found between the heat difference before and after the transition and the egg yolk to egg white mass ratios. When comparing the degree of gluten formation, of the egg yolk components studied, those samples with egg yolk plasma exhibited the longest fragment length of gluten. These results suggested that the type of egg yolk component does not affect the glassy state of sugar. Kuragano et al. (2005) previously reported that the yolk or the emulsifier accelerated the homogeneous dispersion of fat in the dough and the binding of wheat protein with water in the dough. The emulsifiability of low-density lipoprotein in egg yolk plasma might thus enhance the adsorption of water by wheat protein and promote gluten formation and increase the *kuchidoke* sensation.

Oral

Textural, nutritional and sensorial characterization of cookies fortified with almond okara, the by-products of almond milk production

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Objective:
Dairy alternatives market will grow in the next years at an estimated rate of 9.9% by 2025 and almond milk is expected to grow at a CAGR rate of 15.2%. Almond okara (AO) is the solid residue by-product derived from almond milk production containing the water insoluble components of almonds (dietary fiber, lipids and proteins). From the perspective of promoting the re-use of food industry by-products, AO obtained from two almond cultivars and subjected to two drying methods was characterized and used as functional ingredient for biscuit preparation.
Methods:
AOs derived from the production of almond milk from two cultivars (Texas cv and Filippo Ceo cv) and subjected to two drying methods (oven vs freeze-dried), was characterized in terms of chemical composition, technological properties and quality of the lipid fraction. The freeze-dried AO (FdAO) was then used at three level of incorporation (15%, 25% and 35%) in substitution to wheat flour to produce biscuits. Considering the lipid content of AO, the sunflower oil used in the biscuit formulation was adjusted to avoid the increase of the lipid content and the energetic value. The biscuits were characterized in term of textural, nutritional and sensorial features.
Results:
The almond cultivars and the drying method significantly influence the chemical composition and technological properties of the AO. The AO from Texas cv showed a significantly higher protein and lower lipid content compared to the Filippo Ceo cv (16 vs 11% and 42 vs 46 % respectively). The freeze-drying process allowed to obtain higher water absorption capacity probably explained by the formation of a more porous structure during the process. The addition of the FdAO at 25 and 35% of incorporation significantly improves the quality of the lipid fraction and the fibre content of the fortified biscuits that become harder. The sensory evaluation highlights the little impact of the AO on the almond odor, taste, and flavor of the biscuits.
Conclusion:
The AO is a valuable ingredient to be used to improve the nutritional features of food. The biscuits formulated with AO showed improved nutritional composition, with a minimal impact on the sensorial aspects.

Oral

From bread to digesta: How superfine-milled purple whole wheat flour affects bread performance, human sensory evaluation and in vitro starch digestion

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Purple wheat has been well recognized for its high nutrition value, especially for the anthocyanins concentrated in its pericarp layer. To increase the intake of anthocyanins and dietary fibre while mitigating the undesirable quality deterioration caused by bran in the end product, superfine milling was employed to yield micro-size whole-purple-wheat flour (WPWF). The purpose of this work was to evaluate organoleptic qualities via instruments and human panels, as well as the glycemic potential via *in vitro* starch digestion of bread made from superfine-milled whole-purple-wheat flour (SWPWB). Results from the instrumental analysis showed the superior quality of SWPWB in specific volume (SV), hardness, chewiness, cohesiveness, and springiness. SWPWB was more porous and less hard with a significantly higher specific volume (Hardness: 3.63 N; SV: 3.21 mL/g) than bread made from commercial superfine whole wheat flour (SWB; Hardness: 10.88 N; SV: 2.30 mL/g). Temporal check-all-that-apply (TCATA) allowing for describing multi-dimensional sensory properties was applied for 8 attributes to bread texture. Similar to instrumental analysis, the obtained ratio of perception from 13 trained human assessors during TCATA evaluation, indicated that SWB was denser, while SWPWB was significantly more aerated. *In vitro* digestion was conducted according to the standardized INFOGEST protocol, including oral, gastric, and intestinal phases. The *in vitro* digestograms were fitted into the first-order kinetic equation. Comparing the obtained rate constant (k) revealed that the SWPWB significantly slowed down the digestion rate (k = 0.0045 min^{-1}) as compared to the SWB (k = 0.0068 min^{-1}). Furthermore, the predicted glycemic index value of SWPWB was significantly lower than that of SWB. These findings suggest that purple whole wheat bread with higher acceptability and commercial potential, is promising to be a healthier alternative to not only refined carbohydrates but also conventional wholegrain products.

Oral

The role of saliva in the sensory perception of textures of semisolid foods

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Perception of texture is a dynamic process that occurs as a food is orally processed. While most research in the area of oral processing and sensory perception has focused on hard solid foods, the contribution of oral processing to sensory perception of semi-solid foods is less studied. A semi-solid food matrix is a soft structure and requires little in the way of force to break. Saliva is a main contributor to changes to the bolus during oral processing of this type of matrix due to the interactions between the food and salivary components. The exact contribution of saliva to texture perception of the bolus is yet to be elucidated. The aim of the current work was to examine the relations between salivary input during oral processing and the temporal aspects of texture perception as it occurs with starch thickened purees. Using samples of pureed carrot matrices thickened with starch as a model system, sensory and instrumental tests were conducted. Temporal dominance of sensations results revealed that samples were perceived as thick and grainy throughout oral processing. Instrumental viscosity measurements, carried out by adding fresh stimulated saliva or water to the samples showed that viscosity did not differ between low starch concentration samples with saliva and with water, however at higher starch contents, viscosity was significantly lower when the product was mixed with saliva. This suggests that starch hydrolysis may be occurring. To further examine this, the oral starch breakdown of the bolus was measured in vitro, at three different time-points simulating the different stages of oral processing. The amount of maltose released from the product was used as an indicator of the degree of starch hydrolysis. Sensory perception of viscosity at these specific time-points was also measured using Progressive Profiling. Small variations in maltose release among starch concentrations and over the time of oral processing were observed and may explain some of the differences in perceived viscosity found with sensory testing. Results indicate that it is important to incorporate saliva into instrumental testing to better understand dynamics of texture perception of semi-solid foods.

Oral

A custom-manufactured tribometer to analyse friction between rough and lubricated biomimetic tongues and an artificial palate

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Food oral processing is a key step in food consumption, that has a substantial influence on how consumers perceive food. Advancement in understanding this process has been recently aimed at tribological investigations that focus on the behavior of surfaces in friction through thin film lubrication. Objective To mimic the conditions in the mouth, a custom-manufactured tribological setup was employed to investigate friction mechanisms occurring in presence of rough and deformable artificial tongues, under the effect of lubrication by Newtonian solutions of glycerol. Methods Tongue mimicking surfaces with modulated roughness that had asperity heights ranging from 20-150 µm mimicking those found in humans were manufactured from solutions of polyvinyl alcohol. Newtonian aqueous solutions of glycerol covering a wide range of viscosity ranging from 1 to 1400 mPa.s were used as simple food models and spread on the artificial tongues. The tribological behavior of the system was studied during shear back and forth movements where the amplitude was 10 mm; velocity: 10 mm.s-1; with the initial normal stress being set to 9 kPa. Results The signals of the ratio between tangential and normal forces were analyzed both in terms of average values and of fluctuations, over specific time periods set at the end of motion and rest steps. Consistently with the mixed lubrication regime, the average values of friction level were reported to increase when (i) the roughness of the tongue mimicking surfaces increased and when (ii) the viscosity of glycerol solutions decreased. The fluctuations of friction level that can be associated with stick-slip events were for their part generally of higher amplitude as the roughness of the surface increased. The peak spectrum frequencies related to these fluctuations mostly ranged from 10 to 20 Hz. Conclusions The study demonstrates the importance of (i) the biological relevance of tongue properties (contact areas, rigidity, and asperity heights) and (ii) the thorough analysis of force signals to better understand the complex mechanisms of friction occurring in the mouth during food consumption.

Oral

Controlled satiety and nutrient digestion through a proper design of 3D food architecture

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The worldwide prevalence of diet-related diseases such as obesity is one of the main food related health concerns, which urges innovative solutions. Among the different approaches developed to address this problem, the modification of food structure and/or appearance deserves attention due to its influence in implementing food perception and eating behaviour, as well as biophysical transformation of nutrients in the gastrointestinal tract.
The possibility of controlling the satiety perception and the nutrient digestion of food products has been studied by exploring their interrelations with external (shape and dimensions) and internal (voids and solid fractions, pores morphologies, etc.) 3D properties of food products. With this aim, cereal-based snacks having morphological diversities and different level of 3D complexity have been obtained by using 3D food printing technology that is capable to convert any 3D digital model into food structures. The samples were described for the texture properties, in vitro nutrient bioaccessibility and microstructural metrics. Then, three consumer's groups at different age were selected and they were asked to eat the samples while the mastication behaviour was detected by using EMG analysis. Lastly, the panellists were invited to rate their perceived satiety.
This work shows the successful development of food products with diverse structures affecting some food attributes, as well as the nutrient digestion and the oral breakdown. In addition, it was possible to relate food structure with perceived satiety which was different among consumers at different age.
This study contributes to the understanding of how to control nutrient digestion and satiety by means of a proper design of food structures with tremendous consequences on the human health. For instance, it could be possible to realize food products inducing a rapid satiety thus decreasing the intake of calories or some unhealthy nutrients, e.g. sugars, saturated fats, etc. On the contrary, other food structures could generate a delay in the satiety sensation, so causing a higher consumption of food products in persons who have the need to increase the intake of some micronutrients.

Oral

A method for evaluating the texture of hamburger patties using an artificial bolus

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Tactile stimuli to the oral cavity during mastication cause the sensation of food texture. The intensity of the stimulus depends on the physical properties of the food bolus. It is highly likely that temporal changes in the stimulus intensity, i.e., the changes in the physical properties of the food bolus during mastication, influence the sensation of food texture. In the present study, we developed a masticatory apparatus which can program mastication speed and stroke and the flow rate of artificial saliva, and investigated the relationship between the temporal changes in the physical properties of the food bolus and the sensory evaluation of the hamburger patty.

The textural properties of nine commercially-produced hamburger patties (graininess, crumbliness, and juiciness) were evaluated by Quantitative Descriptive Analysis to select four products for measurement of the physical properties of their boluses. The particle size distributions (PSD) of the granular material in the boluses collected at mastication from human participants in the experiment or from the masticatory apparatus were measured by sieve analysis using mesh sieves from 0.212 to 31.5 mm. The average rates of saliva absorption by the bolus were determined for each of the four hamburger patties. Comparing the properties of the human bolus and the artificial bolus allowed the optimal values of the mastication speed/stroke, the optimal flow rate of artificial saliva, and the optimal shape of teeth to be determined.

The results from the human bolus and artificial bolus showed that the PSD with a 25% passing rate (D25) value became smaller for samples whose crumbliness score became higher at mastication periods of 10 s or more. The Temporal Dominance of Sensation results showed that as the scores of juiciness and crumbliness increased, the onset time when the bolus comes together occurred earlier. The patterns of temporal changes in the PSDs were different for each hamburger patty whose graininess, crumbliness, and juiciness also differed from each other. Such patterns are important and effective for developing hamburger patty products.

Food performances, properties, digestibility & functionalities

Oral

Oral and gastrointestinal digestion of beef burgers supplemented with fava bean (Vicia fava) flour: improvement of nutritional profile

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Meat is a commonly-consumed commodity worldwide and is a rich source of high-quality protein and all the essential amino acids required for adult human needs (WHO/FAO/UNU, 2007). However, due to its environmental fingerprint, meat consumption will decline in the future in favour of legumes. Meat proteins can be partly combined with plant-based proteins to reduce environmental impact, but more importantly to produce healthier formulations targeting specific populations (Baugreet et al., 2019). The present work aimed to determine the improvement of the nutritional profile of beef burgers supplemented with fava bean (Vicia fava) extruded flour after their in vitro oral and gastrointestinal digestion. To this end, beef burgers were supplemented with 10% (w/w) of fava bean flour. After that, samples were cooked until reaching 70 ?C in the core part. In vitro food boluses of control and supplemented samples were prepared with the AM2 masticator using normal mastication programming, which was simulated employing in vivo data. Static in vitro digestion of samples was performed according to INFOGEST method (Brodkorb et al., 2019), with minor modifications. Granulometric analyses of in vitro boluses were run by using a mechanical sieve and the amino acids profile of samples, at the end of oral and gastrointestinal digestion, was determined by HPLC coupled with a fluorescence detector. A one-way ANOVA test, followed by Tukey-Kramer post-hoc test, was performed to evaluate differences among samples and were considered statistically significant at $p < 0.05$. In vitro boluses of supplemented burgers showed greater median particle size values (d50) than control ones. At the end of the in vitro gastrointestinal digestion, greater amounts of essential amino acids such as isoleucine, leucine, lysine, phenylalanine, tyrosine, valine, and tryptophan were noted in supplemented burgers. Leucine, together with isoleucine and valine, is an amino acid of concern in the elderly due to its participation in muscle protein synthesis (Rémond et al., 2015). These results confirm that the supplementation of meat products with 10% of fava bean (Vicia fava) flour improves its nutritional profile, which plays an important role in specific populations like the elderly. In addition, such an initiative contributes to environmental concerns.

Food performances, properties, digestibility & functionalities

Oral

Structure, physical breakdown and functionality of third-generation snacks enriched with catechins using a human gastric simulator

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Depending on the formulation and the processing conditions used, extrusion can either lead to an expanded product or to a minimally expanded pellet. In this case, pellets are expanded afterwards, in an independent thermal device (e.g. oven), leading to a third generation (3G) snack. Several structural changes occur during both unit operations, and a clear relationship between processing variables, the structure of pellets and expanded products must be further understood. Similarly, the retention of functional compounds that may be added, such as polyphenols, in conjunction with the effect on structure development and subsequent digestive breakdown after expansion is of scientific and technical interest.
We analyzed the effect of extrusion temperature (110, 135°C, and 150°C) and moisture content (27, 29 and 31%) in rice-flour pellets and their microwave expansion, through a microstructural approach using micro-CT. In addition, we examined the effect of processing conditions on catechin retention (HPLC), antioxidant capacity (DPPH and ORAC) and total polyphenol content (TPC) in catechin-enriched products. In vitro essays were developed using a dynamic gastric model (Human Gastric Simulator-HGS), to examine the antioxidant capacity and starch hydrolysis, together with the physical breakdown of the expanded pellets, during gastric and intestinal digestion every 30 min (30-180 min).
Results showed that the highest pellet expansion was obtained at the lowest moisture content (27%) and the highest extrusion temperature (150°C), in both categories with and without catechin addition, probably due to an increased friction inside the extruder barrel. These pellets, in turn, led to the highest expansion after microwave heating (50 s, 800 W). Interestingly, in all pellets a lower catechin content was measured compared to the one measured in the expanded ones (59 ± 6% and 94 ± 6%, respectively), probably due to the pellet dense glassy structure, which entrapped the phenolic compounds precluding their release. HGS essays determined that the highest antioxidant capacity (~336 µM Trolox/g dry matter) was also obtained in expanded pellets that were prepared with the lowest moisture content and were processed at 150°C. However, all samples reached a similar level after 180 min of gastric digestion and the average bio-accessibility was 54%.

Food performances, properties, digestibility & functionalities

Oral

Nutritional benefits of sourdoughs: LESAFFRE scientific position

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Nutritional benefits of sourdoughs: LESAFFRE scientific position
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Scientific literature on nutritional benefits of sourdough breads includes numerous studies on micronutrient (vitamin and mineral) bio-accessibility, glycemia, bioactive peptides or impact on gut microbiota. Sourdough fermentation is increasingly considered among the public as a process yielding nutritional benefits, while reliable and relevant scientific evidence is still unclear or missing. Herein we propose to explore this issue and enlighten what is beneficial for consumers and what remains to be investigated.

We did a systematic review of literature to identify bread nutritional properties and related breadmaking processes: 239 articles were retrieved and investigated. Among these articles, nutritional properties specific to sourdough breads were identified and analyzed from 29 clinical, 8 preclinical and 95 in vitro studies.

Our investigation revealed that the combination of wholegrain flours with sourdough fermentation in specific conditions could have a beneficial effect on mineral bio-accessibility, glycemic response, satiety and gut health (gluten and FODMAP reduction, fiber content). However, many factors influence bread properties such as sourdough microbial composition, fermentation parameters, cereal as well as flour types. Processes and recipes variability did not allow us to draw clear conclusions on the isolated effect of sourdough fermentation.

In summary, our literature review showed that bread made from wholegrain flour combined with sourdough fermentation can provide nutritional benefits but more studies (In vitro, In vivo) with standardized approaches are required to investigate the benefits of sourdough fermentation in other conditions.

Food performances, properties, digestibility & functionalities

Oral

Development of Quantitative In Vitro-In Vivo Relationships to Understand Food Digestion Processes

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As development of functional foods has increased, parallel advancement of in vitro model systems has occurred to facilitate food product testing. With the development of novel in vitro digestion systems and methodologies, a quantitative framework is needed to develop appropriate in vitro-in vivo relationships such that results between in vitro and in vivo tests can be easily compared. The Human Gastric Simulator (HGS) was utilized to conduct in vitro gastric digestion of two carbohydrate-based foods of varying structure that were previously studied in vivo using a growing pig model (cooked fettucine pasta and semolina porridge). During in vitro digestion in the HGS, gastric secretions were added at a rate of 4.1 mL/min and gastric emptying was controlled at 5.62 g/min for both meals. Both the gastric emptying and gastric secretion parameters were determined based on average values across six carbohydrate-based meals from a previous in vivo study in growing pigs. During in vitro gastric digestion, samples were taken from the bottom of the HGS at 30 min intervals up to 240 min and the pH, dry matter gastric emptying, texture, particle size distribution, and starch degree of hydrolysis were measured in the emptied digesta. Emptied digesta pH was greater in semolina (4.35 – 1.58) compared to pasta (2.23 – 1.21), likely due to differences in buffering capacity between the meals. During gastric digestion in the HGS, the dry matter half emptying time of semolina was 57.75 ± 1.96 min compared to 163.25 ± 18.28 min for pasta. These trends align with in vivo results, where pasta also had a slower dry matter gastric emptying half time compared to semolina (360 vs. 88 min, respectively). Quantitative correlations between the in vitro and in vivo results were developed to compare dry matter gastric emptying, starch hydrolysis, digesta texture changes, and digesta moisture content, with R2 values ranging from 0.4375 – 0.9955, depending on the measurement and meal type. Information on quantitative in vitro-in vivo relationships will be crucial in engineering the next generation of in vitro model systems that can be utilized to develop future foods with healthy benefits.

Food performances, properties, digestibility & functionalities

Oral

Gut fermentability of supramolecular assemblies: A case study on ?-lactoglobulin and ovalbumin nanoparticles and amyloid-like fibrils

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Processing may induce protein structuring, for example amyloid-like protein fibrils may form during spray or freeze drying. However, the link of amyloids in human pathogeneses raises concern over their formation in foods. Therefore, this study fabricated various protein architectures, characterized them, and studied their digestive fate. Changes in pH and temperature (pH=2, 37-80°C) were applied to β-lactoglobulin (BLG) or ovalbumin (OVA) to fabricate amyloids fibrils (AF) that were characterized by DLS and TEM as well as Thioflavin T assay to affirm amyloid arrangement. These assemblies were subjected to semi-dynamic *in vitro* digestion coupled to LC-MS/MS proteomic analyses and compared to the digestion of the native protein counterparts. In respect to microbial fermentability, amyloid structures were screened for antimicrobial activity against gram negative and positive bacteria, as well as tested for their colonic fermentability using *in vitro* anaerobic fermentations of freshly collected human feces (n=5). Microbiota responses were studied using 16S sequencing and QIIME2.

This work provides evidence that amyloid structures attenuate the digestive proteolysis of BLG and OVA in the upper GI. This is shown by reduction in the abundance of bioaccessible peptides upon digestion. Antimicrobial activity of OVA (e.g., MIC=21mg/mL against *micrococcus luteus*) was abolished by amyloid formation. Colonic fermentation results strengthen this finding as alpha-diversity scores (observed features) were significantly lower ($p<0.003$) for OVA (121±29, n=13) in comparison to OVA-AF (161±27, n=17). This reduction in biodiversity was specific for OVA, as BLC (166±21, n=12) and BLC-AF (166±27, n=16) were similar to FOS (160±30, n=15). Beta-diversity analysis shows OVA fermentation shifts the ecosystem compared to OVA-AF ($p<0.05$) and ANCOM-BC analysis shows specific symbionts of the gut are significantly reduced in relative abundance in the presence of OVA (e.g., *Roseburia*).

Overall, structuring proteins into amyloids attenuates their proteolysis in the upper GI with mixed implications on the diversity of the colonic microbiota. Thus, this work shows that processing can be harnessed to fabricate novel functional protein architectures; however, their digestive fate requires further study to support or refute possible benefits or deleterious effects. Altogether, this research provides evidence that show amyloid structures may be engineered to modulate gut nutrition.

Oral

Characterizing the rheological properties of cellulose nanocrystals in the stomach using a dynamic in vitro model

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Previous studies indicated that cellulose nanocrystals (CNC) can form hydrogel networks during gastric digestion, resulting in an increased digesta viscosity. This property could contribute to delayed gastric emptying and increased satiety feeling which is beneficial to disease management such as obesity and diabetes. The objective of this study was to investigate the influence of pH levels and ionic strengths present in the gastric environment, and dynamic gastric conditions on the rheological properties of cellulose nanocrystal (CNC). Sodium alginate (SA) and pectin (PE), which are widely studied for their gel formation properties in the stomach, were studied as a comparison.

CNC suspension at 4%, 6%, and 8% (w/w) concentrations, and sodium alginate and pectin solutions at 2%, were prepared with deionized water. The effect of pH was studied by adjusting the pH of the samples to 1.5, 2.5, 3, and 5, respectively, followed by viscosity measurement. The effect of ionic strength was studied by adding a series of concentrations of CaCl2 and MgCl2 solutions to the samples and analyzing the changes in the rheological properties. A dynamic gastric simulator model (DGSM) was used to test the behavior of the CNC, SA and PE samples during gastric digestion. The rate of gastric emptying was recorded during the 2 h simulated digestion.

CNC formed strong hydrogel at low pH (1.5) and high concentration (8%). Both CaCl2 and MgCl2 addition enhanced the formation of CNC hydrogel, while Mg^{2+} is more effective than Ca^{2+}. SA developed a viscous gel with the addition of salt addition, and Ca^{2+} led to a thicker and more potent gel network. In contrast, no significant effect of ionic strength on pectin gelation was observed. During dynamic gastric digestion, SA formed a strong gel network in the stomach delaying gastric emptying. CNC formed hydrogel to a different extent depending on the concentration while not significantly affecting gastric emptying. No gel formation was observed for PE.

This study provided useful information on the behavior of CNC and other polysaccharides during gastric digestion, which could promote the potential application of CNC in functional foods aiming to delay gastric emptying and reduce calorie intake.

Food performances, properties, digestibility & functionalities

Oral

How inclusion of semi-dynamic digestion conditions impact the proteolysis and amylolysis kinetics of cooked lentils?

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Semi-dynamic *in vitro* digestion models allow to strategically choose which dynamic factors to include, filling the gap between static and dynamic approaches. However, few systems are available allowing independent sampling throughout digestion to determine kinetics. Hence, we introduced an automated system (BioXplorer100, H.E.L Group) to simulate semi-dynamic digestion in multiple reactors simultaneously. The digestion conditions used in the different reactors in the first part of this work were *(i)* gradual pH change and enzyme secretion in the stomach (based on INFOGEST protocols) and *(ii)* gradual enzyme and bile salt secretion in the small intestine.
Different digestion patterns were observed when comparing static and semi-dynamic kinetics for cooked lentils. For the static approach, proteolysis increased rapidly until a plateau was reached. For the semi-dynamic approach, the start of proteolysis was retarded, which was related to the decreasing pH and large pH-dependency of pepsin activity in the stomach. Additionally, during intestinal digestion, a shorter lag phase was noticed, yet clearly present. This was explained by the gradual enzyme secretion, which resulted in a period of enzyme competition before proteolysis occurred at maximum rate.
In the second part, the choice of which additional parameters to include in such semi-dynamic simulations and their impact on digestion kinetics was investigated. For example, salivary α-amylase remains active during the initial period of the gastric phase due to the gradual pH decrease. However, static models mostly do not introduce this enzyme as it is immediately inactivated at the static pH of 3. The action of salivary α-amylase can impact the subsequent amylolysis kinetics of, *e.g.*, pulses.
Introducing salivary α-amylase followed by a semi-dynamic gastric phase showed that starch was significantly hydrolyzed in the orogastric phase. Consequently, amylolysis extent was higher at the start of the small intestine compared to static conditions. This difference was not compensated by the action of pancreatic α-amylase, resulting in a higher final extent of amylolysis. This was most probably related to the specific actions of both enzymes, hydrolyzing different starch bonds.
Overall, we showed that the BioXplorer100 could be used to mimic semi-dynamic digestion conditions and determine more physiological relevant digestion kinetics.

Food performances, properties, digestibility & functionalities

Oral

Perspectives of protein bio-encapsulation to tailor its digestion kinetics in plant-based drinks

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Plant-based drinks are commonly emulsified systems containing purified macronutrients from plant origin. These drinks are nowadays greatly consumed because people are more aware of the impact of food on health, animal welfare, and the environment. The utilization of pea protein in these products is growing due to its high nutritional value, low allergenicity, and availability. Importantly, the macronutrient structure and accessibility significantly influence the digestive functionality of these drinks. In this regard, the goal of this project was to design plant-based drinks containing protein in two forms: dispersed and bio-encapsulated and at different ratios. The drinks were prepared by combining two independent streams: (i) basic drinks, containing dispersed protein from pea protein isolate (PPI), and high oleic acid sunflower oil (HOSFO), and (ii) individual pea cell (IPC) suspensions, containing bio-encapsulated protein. For all drinks, their overall composition was 5% HOSFO, 6% protein, 1% soy lecithin, and 88% water (w/w). The ratio of protein derived from IPC and PPI was modified, yet, the total protein content was kept constant (6%). All drinks were digested to study the impact of the protein structural organisation on proteolysis kinetics, as well as on the digestion kinetics of co-ingested lipids and starch (if present). The results showed that increasing the IPC content (5% versus 15%) significantly decreased the extent of protein (75% versus 68%, respectively) as well as starch (63% versus 47%) small intestinal digestion after 120 min. Moreover, drinks having a greater extent of proteolysis presented a greater extent of amylolysis. Finally, higher IPC content (15% versus 5%) presented a lower extent of gastric lipolysis (44% versus 56%) which was leveled out during the small intestinal phase (>80%).
Our findings confirmed that combining dispersed and bio-encapsulated protein, is an interesting approach to modulate macronutrient digestion kinetics. Increasing the content of bio-encapsulated protein in this particular case, resulted in a lower susceptibility of substrates to enzymatic breakdown. This might be a promising strategy in the design and formulation of liquid food products with slow/low macronutrient digestion for satiety effects and weight control purposes in tailored populations.

Food performances, properties, digestibility & functionalities

Oral

Bread fortified with betacyanin-rich extract from red dragon fruit peel as nutraceutical sources: Its baking performance, antioxidant activity, and in vitro digestibility

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Betacyanins are a class of water-soluble and red-violet pigments that have attracted increasing attention due to their promising bioactivities. Red dragon fruit peel (RDFP) is a rich source of betacyanins, which is commonly discarded as a waste during processing and consumption. Herein, betacyanins were extracted from RDFP and purified by solid phase extraction to obtain a betacyanin-rich extract (BRE). BRE was subsequently incorporated into bread and its effects on bread baking performance, antioxidant activity, and in vitro digestibility were studied. The baking quality of the bread fortified with 0.25, 0.5, and 0.75% BRE was not significantly ($p > 0.05$) different from the control bread, in terms of specific volume, texture, and crumb cellular structure. However, the antioxidant activity of the BRE-fortified bread was enhanced in a dose-dependent manner. Compared to the control bread, the 0.75% BRE-fortified bread exhibited a 2.7-, 1.7- and 4.1-fold stronger antioxidant activity measured by the total phenolic content (TPC), 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), and oxygen radical absorbance capacity (ORAC) assays, respectively. Furthermore, results from in vitro digestion demonstrated that the glucose release rate of 0.75% BRE-fortified bread was significantly reduced in comparison to the control bread. Overall, the present study outcome suggests the potential of BRE from RDFP as a promising functional food ingredient in bread, providing consumers with a higher intake of antioxidants and a slower increase in postprandial blood glucose, without a compromise of sensory quality.

Poster

TOWARDS THE DEVELOPMENT OF A PLANT-BASED CHEESE ANALOGUE: APPLICATION OF COMMERCIAL STARTER CULTURES

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Keywords: Cheese analogue, Lactic Acid Bacteria, Fermentation, Dairy-free, Plant-based,

The search for, and the development of plant-based cheese-like products have been increasing worldwide, driven by sustainability, health, ethical reasons, convenience and social trends. Highly targeted fermentation approaches have been used given their positive impact on sensory, nutritional, and technological properties.
The present work aims to evaluate the best growth conditions of commercial starter-co-cultures, on the fermentation of plant-based food matrices, towards the development of a cheese analogue.
Upon previous selection of the best conditions for oxygen tolerance (aerobiosis) and % of inoculum (0.5%), VegaTM Vibe (VV) (Chr.Hansen) was inoculated in MRS Broth and studied at 37°C, 40°C and 44°C, and microbial growth and pH were monitored over 24 h. Afterwards, VV was inoculated in a plant-based cheese formulation under the previous conditions and the same parameters were measured. Lastly, VV was studied in combination with 3 adjuvants starter cultures (Lactiplantibacillus plantarum - LP, Lactobacillus helveticus - LH or Pediococcus - P) in 3 co-cultures (VVLP, VVLH, VVP) inoculated at 0.5% and 0.25% (1:1, v:v), and incubated at 44°C, aiming the selection of the most effective combination in terms of acidification, to be further used.
In MRS-broth, the less favourable temperature was 44°C, while no differences in growth were observed between 37°C and 40°C. For the inoculation in the plant-based formulation, the highest temperature did not seem to be so impactful, and it was observed an increase of almost 1 log cycle over 24 h. In what concerns the 3 co-cultures, the combination that resulted in a faster acidification was VVLP, having reached pH ~5.5 in less than 90min, when inoculated at 0.5%, followed by VVLH and VVP. When inoculated at 0.25%, the co-cultures took more time to reach the same pH (130min, 180min, and 210min, for VVLP, VVLH and VVP, respectively).
The plant-based formulation seems to promote the growth of the starter-culture VV singly cultured or in co-culture with adjuvants starters, when inoculated at 0.5%, in aerobiosis, and incubated at 37-44°C. The most effective co-culture in reaching the pH of 5.5 in the least time was VVLP, showing promising results for its application for the development of cheese analogues

Food performances, properties, digestibility & functionalities

Poster

Rheological methods for plant proteins based foods: characterization of ingredients and final products, formulation and processing

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Plant proteins based foods have become a huge topic during the last few years. The key issue for establishing them in the market is to achieve sensory acceptance of consumers, which relates to both food structure and taste. Rheological methods are beneficial not only to check the quality or functionality of single ingredients or to characterize different formulations but also to mimic processing steps such as cooking of the final product.

The characterization of different protein samples is carried out by exposing the samples to a heat-hold-cool temperature profile while stirred in a rheometer set-up. The viscosity is monitored to characterize the samples during the different stages of the temperature profile. Additionally, commercially available plant proteins based foods were exposed to oscillatory shear flow to characterize their viscoelasticity and hence its structure and texture Measurements were conducted both a room temperature and at higher temperatures, to mimic the cooking process.

We can show that that rheological characterization is of greatest interest for the formulation of plant proteins based foods. Both, single ingredients as well as final products can be characterized in an easy and time-saving analysis. When comparing the vegan food alternatives products with their non-vegan counterparts, the direction of future developments and formulation can be evaluated.

Food performances, properties, digestibility & functionalities

Poster

Evaluation of the Chemical, Functional and Textural Properties of the Parboiled Amaranth (Amaranthus caudatus L.)

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The parboiling is a hydrothermal process by steaming cooking used in kernels that improves its physicochemical, functional, and nutritional properties. Nevertheless, only few research about the effect of parboiling on the properties of amaranth was reported. In this study, the objective was to evaluate physicochemical, functional, and texture properties of the parboiled amaranth INIAP – Alegría variety from Ecuador. Through a Central Composite Design, the effect of the variables, time (6 - 34 min) and temperature for steam cooking (55 and 84 °C) of the parboiling process in the amaranth kernel was evaluated and the best treatment was determined with multiple response optimization. The best characteristics resulting from the parboiling were obtained at 84 °C for 20 min. The content of moisture, ash, lipids, protein, carbohydrates, crude fiber, starch, and caloric value of the process were: 15.67, 2.41, 0.98, 13.31, 67.63, 6.76 and 62.67 %, and 332.56 Kcal, and in the not treated kernel: 19.56, 2.37, 0.20, 12.94, 64.95, 6.55 and 59.09 %, and 313.28 Kcal, respectively. There were no differences in ash content between the parboiled and not treated kernel, but there were differences in hardness, granule size D [4,3] and IAA, PH, and ISA with values of 3.76 N, 1.59 µm and, 5.64, 6.67 and 15.57 g/g, and respectively, 30.83 N, 0.73 µm, 4.20, 4.62 and 9.10 g/g.

Poster

Phenolics compounds in high plant protein drink developed with honey microencapsulated to evaluate the bioaccessibility

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Phenolic compounds contained in food have gained great interest in the food industry and consumers. Honey has these minor constituents and provides some health benefits related to their biological effects such as antioxidant capacity. However, it is important to evaluate the quantity of these compounds that are liberated from the food in the gastrointestinal tract and the amount that become exactly accessible for absorption. This study aimed to develop a high plant protein drink produced with microencapsulated honey and to evaluate the bioaccessibility of the phenolic compounds. A high plant protein drink formulation was developed with microencapsulated honey, which was produced by spray drying using rice protein as a carrier and physicochemically characterized. Microencapsulated honey characterization was performed regarding moisture content, water activity (aw), particle mean diameter, wettability, water holding capacity and solubility. Bioaccessibility of the phenolic compounds in the high plant protein drink was performed using the INFOGEST® static in vitro digestion protocol. Total phenolic compounds (TPC) from honey and the microencapsulated honey were performed using the Folin-Ciocalteu reagent. The moisture content of the microencapsulated honey was 6.53 ± 0.13 g/100 g. The aw value during 60 days of storage time was less than 0.6. The particle mean diameter was 65.85 ± 23.53 µm, which can be considered a proper size when aiming to add those particles to a food matrix. Wettability, water holding capacity and solubility were 8.3 ± 0.6 s, 1.16 ± 0.01 g/g, 45.67 ± 0.51 %, respectively. The high plant protein drink formulation contained 25 g of protein and 18 g of sugar/honey in a portion of 250 mL. TPC found for honey was 1002 ± 88 mg GAE/kg of honey. On the other hand, TPC found for the honey microencapsulated was 230 ± 24 mg GAE/kg of honey, having a recovery of 73 %. Preliminary tests showed that was possible to perform the bioaccessibility of phenolic compounds in a high plant protein drink using the static in vitro digestion protocol and the phenolics profile generated from the digested samples will be assessed by liquid chromatography mass spectrometry (LC-MS/MS).

Food performances, properties, digestibility & functionalities

Poster

Optical determination of fiber orientation and anisotropy of plant based high-moisture meat analogues

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Keywords: Processing, Product, high moisture extrusion, plant based meat analogues, anisotropic fibrous structure,

Meat is a highly hierarchically structured material and many of the textural properties of meat are highly dependent on its internal structure both micro and macroscopically. For high-moisture meat analogues, in addition to textural properties, fiber structure is a key factor in consumer acceptance. The mechanical performance of the final material is affected by the length of the fibers, their thickness and orientation, as well as by the adhesion between the fibers and the matrix. Although several techniques have been developed to quantify fiber formation in extrudates, their application for real-time quality control in industrial processes is challenging. In the present study, we tested a simple and easy-to-implement non-destructive optical method that quantifies fiber structure and anisotropy in plant-based high-moisture meat extrudates. According to the continuous-time random walk theory, light propagation anisotropy is a distinctive optical property of any material caused by preferentially oriented microstructures such as fibers that scatter or transmit light propagation. It is therefore possible to determine the level of matrix structuration by measuring the anisotropy of light propagation through a given fibrous material. For samples with a more isotropic structure, the light transmission probabilities are equal in all directions, resulting in a circular light scattering pattern. On the other hand, a direction with a minimum value of light scattering can be related to the direction of fiber orientation, which forms a reflection ellipse with the main axes oriented in the direction of the fiber. A modified image processing method was used to extract information about the level of anisotropy of the illuminated samples. Iso-intensity contour plots were used to describe the anisotropy of light propagation, as they represent the range of propagated light of equal intensity. The resulting iso-intensity contours were processed to obtain shape descriptor information, provided that a perfect circle represents an isotropic structure and a highly elongated ellipse represents an anisotropic structure caused by different levels of fiber orientation. The results were in good agreement with data obtained by confocal laser scanning microscopy, where the same fibrous structures were also visualized and quantified.

Poster

Functionalization of brown seaweed aqueous dispersions by physical treatments

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Keywords: seaweed, thermal treatment, high pressure homogenisation, rheology, cell wall, food structure,

The food demand is increasing worldwide due to demographics and challenges associate with climate change. As a result, there will be the need for a more sustainable exploitation of land and aquatic raw materials as a source of nutrients and of specific techno-functional properties of relevance for agrifood and other industries such as pharmaceuticals, biomaterials and biofuels. The interest to use seaweed in food products has increased, partially due to their nutritional value based on their content of dietary fibre, unsaturated fatty acids and protein. Furthermore, seaweed cell wall polysaccharides have structuring properties and have been used in food industry as viscosifiers and gelling agents during decades. However, these ingredients are industrially produced by energy costly methods, and may leave large amounts of unused side streams. Furthermore, they can be perceived as artificial by the consumers. An alternative could be to exploit the natural texturiser potential of cellular materials *i.e* cell clusters, cells and cell wall fragments containing polysaccharides with texturising abilities. However, in order to utilise seaweed as a whole ingredient a fundamental understanding of the relationship between processing conditions, cell wall structure and techno-functional properties is required. In particular, knowledge regarding rheological properties relevant for manufacturing conditions, food texture and nutrient bioaccessibility is needed. Brown algae are known to be a rich source of fiber i.e cell wall polysaccharides with the presence of several non-digestible polysaccharides including laminarin, fucoidan and alginate, the latter is particularly abundant in Laminaria species. Here we investigated the impact of physical treatments (thermal and mechanical) on the stability and the rheological properties of dispersions of two brown algae *Laminaria digitata* and *Saccharina Latissima* (5 % wt). Results showed that the mechanical treatment was the main parameter affecting rheology of the dispersions, whilst the thermal treatment and botanical origin had less impact. Flow behaviour and viscoelastic properties were explained based on the monosaccharide composition, nano- and microstructure as well as particle size distribution of the dispersions. The outcomes of this research give insights into the exploitation of brown seaweed in complex fluids and soft materials for food, pharma and other technological applications.

Food performances, properties, digestibility & functionalities

Poster

Measurements of mechanical properties of hydrated and cooked lentils

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Keywords: compression, hydration, gelatinization, module, method,

The transformation of lentils by hydrothermal treatments, leads to a great diversity of texture of the seeds. There is a need to develop a common rheological method to assess the texture of cooked lentils in order to improve and select varieties best suited to cooking. Texture changes obey different mechanisms, i.e. the evolution of the water content in the seed, starch gelatinising (or melting), proteins aggregating, the complexity of which is increased by the heterogeneity of the seeds. In this context, the aim of this work is to develop a method to measure the mechanical properties of hydrated and cooked lentils.
In this purpose, systems comprising mobiles of different diameters (0.6, 3, 10 mm) are applied in compression to different quantities of lentils (1 single, vs 17 g in a cell Æ 40mm). The selection of the measurement method is based on tests of repeatability, expressed by the error inherent in each method, and on their ability to distinguish between different cooking conditions and batches. For example, on the system (Æ 10mm), the apparent modulus of a cooked lentil decreases from 10 MPa after 8 minutes of cooking (T=95°C), to 1MPa when it is cooked for 25 minutes, with a relative error of 10%. The cooking kinetics at different temperatures are determined and adjusted by a simple mathematical model (Peleg, 1988), in order to determine the influence of the water content on the texture of the lentils. Starch transition temperatures and % gelatinized starch are determined by Differential scanning calorimetry (DSC). In complement, a device similar to Mattson cooker, equipped with 24 metal rods of 80g, each rod deposited on a lentil, is developed to determine the distribution of cooking time, and assess the heterogeneity of the lentil batches.

Food performances, properties, digestibility & functionalities

Poster

Exploring the Correlation Between Flow Speeds and Physical Properties of Food Matrices

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Keywords: Dysphagia, Food properties, Food Matrices, Machine Vision,

Dysphagia is a condition that creates difficulties in chewing and swallowing. If left unaddressed, dysphagia can lead to malnutrition, dehydration or even recurrent pneumonia. For fluid intake, it is possible to mitigate the effects of dysphagia by decreasing the rate of fluid flow. However, the methods currently used to measure fluid thickening are either difficult to use, destructive, not very reproducible, and require precise equipment. Furthermore, the methods are known to be poorly correlated with primary physical properties of food matrices and clinical impacts. Measurement of the flow tests of various food matrices and of different physical properties showed weak correlations. This highlights of our work demonstrated the need for the development of an easy, fast, non-destructive method of taking measurements using everyday objects, leading us to explore novel methods using novel approach such a machine vision.

Poster

Relationship between rheological properties and gluten network structure in wheat flour dough

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Understanding the mechanical behavior of the wheat flour dough is a crucial step for the baking industry, not only to optimize end product quality, but also to save time and cost by producing a processable dough. Dough behavior is determined by its rheological properties, obtained at mixing, the first step of the process. Thus, the objective of this work is to accurately and simply determine the dough processability in the production line. In this purpose, we have analyzed dough structure and rheological behavior for different mixing conditions, and investigated the effects of dough elongational properties on the mixing power curve P(t).
Commercial wheat flours were selected according to their distinct mixing behavior, determined by P(t). Doughs were then prepared in the Farinograph, at different mixing times and hydration levels. The thermo-viscoelastic behavior of the dough at small deformation was determined by dynamic thermomechanical analysis (DMA) and the bi-extensional properties (at large deformation) by the lubricated uniaxial compression test (LSF). In addition, confocal scanning laser microscopy (CSLM) was used to investigate the gluten microstructure.
DMA results are followed by the ratio E'max/E'min, evaluating the gluten cross-linking: the higher the ratio, the less the network is developed after the mixing step. At constant deformation εb, the bi-extensional viscosity of doughs follows a power law, for which the consistency index k exponentially decreases with the dough hydration (R^2 = 0.8) from 47 to 10 kPa.sn (εb =1), for all flours, whereas, at constant hydration, the variation of k during mixing is related to the flour tolerance during mixing, defined by P(t) curve.
In complement, results from spectroscopic method (TD-NMR) showed that four dough hydration states exist which correspond to different structuring gluten network, and hence specific intervals of k values. In line, the main gluten network structural factors obtained by CLSM confirm the relations between hydration states and gluten network structuring.
So, once integrated, these results will allow predicting the gluten network structuring from the mixing curve P(t) and help implement the necessary on-line settings for bakery production.

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Food performances, properties, digestibility & functionalities

Poster

Variability of grain albumen minor components and technological quality of wheat

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Technological wheat quality can be defined as its ability to meet the specifications needed for a given end-use. But this quality assessment is becoming more challenging due to climate change, agro-cultural practices and changing societal demands.
EVAGRAIN is funded by the French National Research Agency and coordinated by the INRAE research unit BIA. The aim of this project is to design a Decision Support System (DSS) that would be able to give a quality assessment of wheat for various end-uses in the industry.
Many studies worked on the genetic and environmental impact on components of wheat grain but mainly focusing on starch and protein. Although these components have a proven role in bread making, minor components, such as lipids and pentosans should also take as much attention. Indeed, lipids have ability to interact with starch polymers and proteins, and have multiple impacts on the dough properties.
Pentosans, which are cell wall polysaccharides, are known for their strong water retention capacity, and water control is crucial in bread making.
This project is part of EVAGRAIN by integrating new wheat evaluation criteria through the study of these minor components of wheat flour.
This work will provide a better understanding of the role of minor components on the quality of grain products. The interconnection of the data and knowledge will allow to create a DSS and determine the most relevant wheat quality criteria for a given use.

Poster

Adding value to legumes through a gastronomic approach: the proof of concept of food models

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Scenarios to face climate change always involve legumes, showing that higher human consumption of local legumes would reduce greenhouse gas emissions. However, human consumption remains lower than recommended, and local production is little valued. The approach of the AGAPE project is to bring added value to both the consumer and the producer through the gastronomic valorisation of pulses.
Two innovative gastronomic recipes developed by chefs were simplified into food models mimicking shortcrust pastry and purees. Each food model was characterized by quality criteria (functionality and sensory) and used to identify the characteristics of seeds and flours correlated to culinarity.
Five species (white and red beans, chickpea, green lentil, and lupin) locally produced in western France were used as seeds or as flour. Grains were characterized by size, weight and hydration capacity; flours by proximate composition, particle size distribution, color, and functional characteristics such as density, and water/oil absorption capacity. For the shortcrust pastry, bake yield, color measurement, textural and sensory analyses were performed and for purees, cooking time, mixing time and texture.
Large variations among the species were noticed in color parameters, bake yield and water absorption capacities. The significant differences observed on the flours (proximate composition, water/oil absorption capacity, particle sizes, and color) could partly explain the variation of the shortcrust characteristics between species. Shortcrust pastries made with lupin highlighted extreme characteristics compared with others legumes, in fibre, protein and lipids. Moreover, fibre contents were positively associated both with water absorption capacity and dough hardness resulting in crumbly pastries. Starch contents were positively correlated with dough springiness, adhesiveness, cohesiveness, and extensibility.
Purees showed large differences in viscosity and compression force depending on the pulses, the beans purees with the highest compression force and the red bean puree the highest viscosity.
The use of food models to predict food quality based on legume seed characteristics seems to be a good way to explore the culinary potential of these species, and to explore new functionalities. This approach is a proof of concept which is further explored in the JACK research project.

Food performances, properties, digestibility & functionalities

Poster

Extrusion simulation for the design of fibre-rich breakfast cereals

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Many starch-based foods, such as texturized ingredients, breakfast cereals, snacks, crackers, pasta, noodles, and many others, are produced by twin-screw extrusion. Despite significant progress in process modelling, the design of extruded products at the industrial level is still based on a trial-and-error approach. The main challenge is determining the viscous behaviour of melts under extrusion-like conditions that require specific rheometers. The 1D global model of twin-screw extrusion Ludovic© has been widely used for the design of experiments of processing, but essentially for simple formulations: maize and wheat starches and wheat flour. Its use in product design has never been tackled before. Then, the work's goal is to test whether this model, implemented with an appropriate viscosity law, can be deployed as a prototype of a computer-aided tool for predicting various properties of fibre-rich extruded breakfast cereals from extrusion operating conditions.

Various food models were selected: blends of wheat flour and wheat bran with bran content up to 26 wt%. A large data set was built from literature data, including foods' properties and extrusion variables (temperature T and specific mechanical energy SME). The foods features were hydro-solubility of starch (WSIstarch), macrostructure described by radial expansion index (SEI) and cellular structure expressed as cell density per cm^3 (NC). Twin-screw extrusion processing was simulated using the 1D global extrusion model Ludovic© (Sciences Computers Consultants, France). The extruder operating charts representing predicted extrusion variables as function of operating parameters were built. From the correlations between predicted extrusion variables (T, SME, melt viscosity η_com) and product features (WSIstarch, SEI, NC), a set of extrusion variables to obtain a product with desired properties can be targeted. Thereafter, the feasible region of operating conditions can be determined from extruder operating charts.

As a future prospect, extrusion simulation will be applied to the design of a wide range of extruded starch-protein blends from pulse crops, including meat analogues. Besides classical structural and functional properties, the textural and nutritional features will be tackled.

Poster

Assessment of modified malted flour's enzymatic activity; focus on amylase and phytase effect for the application of flat bread.

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Flat bread is characterised by a magnified staling effect due to a high heating rate during baking (1) and a small crumb to crust ration. In order to give the bread a flat shape, a rapid baking at high temperatures (ca. 300°C for less than 2 min) yields high heating rates ≥ 80°C/min unlike conventional breads (ca~7°C/min). Malted flour addresses the interest of a natural source of enzymes such as amylase and phytase, which address respectively a reduced staling, and a better availability of minerals in the baked bread. This contribution aims at investigating the performance of a malted flour with focus on the amylase effect applied for flat bread, and the assessme,t of the phytase on different bran fractions. The methodology involved the production of a wheat based malted flour using a conventional germination step (4 days at 18°C). The enzymatic activity was assessed with a Malt-Amylase-kit (Megazyme). Breads were produced at two different heating rates (5 and 40 C °/min) to assess the staling effect from the maltogenic α-amylase. Breads were baked using a miniaturized heating system based on a Pelletier heater (1). The staling was monitored by measuring the Young modulus of the baked crumb and the retrogradation enthalpy of amylopectin during two weeks storage(10°C). The dough stickiness was assessed using a Kieffer-ring system. Amylopectin retrogradation was assessed with calorimetry and the crumb firmness with dynamic mechanical analyser. Phytase activity was asses on different bran fractions for future application. Results showed a significant impact of the heating rate on the kinetics and magnitude of staling. The amylopectin retrogradation was higher with increasing heating rate, whereas no significant dough stickiness was observed. Phytase had higher activity on malted samples than control bran. As a conclusion, the malted flour addresses several challenges in the case of rapid baking conditions such as those encountered with flat bread production. Alternative process strategies should be investigated to favor the enzymes effectiveness in the case of flat bread production. The present work represents a potential clean alternative process for low heating rate-baked products

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Food performances, properties, digestibility & functionalities

Poster

Comparison of microbial transglutaminases from different sources on improving physiochemical properties of plant-based chicken nuggets

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In this study, microbial transglutaminase (MTG) was used to improve the physicochemical properties of plant-based chicken nuggets. The MTGs from different sources were analyzed for its specific activity, optimal reaction conditions, as well as using bovine serum albumin as a substrate to evaluate its ability to catalyze the cross-linking reaction. The physicochemical properties of plant-based chicken nuggets were compared with addition of different MTGs which included recombinant microbial transglutaminase (RMTG), commercial microbial transglutaminase (CMTG), and methylcellulose (MC) as blank control. The results showed that the plant-based chicken nuggets added with RMTG showed a dense and non-porous structure, with the highest water content and water retention capacity compared with the other groups, and there was no significant difference in color and water activity among all groups. In terms of texture, compared with the blank group, the hardness, elasticity and chewiness of the RMTG group were significantly improved, whereas the stickiness was significantly decreased. The texture data of RMTG group was comparable to those of CMTG, and the texture of plant-based chicken nuggets added with RMTG after frying was close to that of chicken nuggets made from chicken. In terms of sensory evaluation, the hardness, elasticity, and chewiness of the RMTG group were remarkably improved, and the stickiness was decreased compared with the blank group. The preference evaluation indicated that CMTG showed the highest preference scores for texture and overall preference compared with blank group and MC. Based on the findings, RMTG has the potential to improve the textural properties of plant-based chicken nuggets.

Poster

Multi-stage block freeze concentration process applied in aqueous extract of Boldo (Peumus boldus Mol.) leaves

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Block freeze concentration (BFC) is an environmentally friendly technology, and it requires lower energy costs, and in addition, BFC presents higher separation efficiency than other concentration techniques such as evaporation or membrane technology, since BFC occurs at sub-zero temperatures [1]. Whereby, different liquid foods have been treated with BFC technique such as juices [2], milk [3], tea [4], among other liquid foods, and in turn, various external forces have been added to the BFC technology to increase process parameters and nutritional properties in the final concentrate [5]. However, an evaluation on specific characteristics in aqueous herbal plant extracts obtained by centrifugal assisted BFC technology has not been studied appropriately. Therefore, the aim of this work was to study the effects of BFC at three centrifugal freezing-thawing steps applied to extracts of Boldo (Peumus boldus Mol.) leaves in terms of physicochemical properties, total bioactive compounds (TBC), and antioxidant activity (AA). After three stages, the concentration (%, w/w) showed a significant increase, with a final value close to 19.7% (w/w) (initial sample 2.4% (w/w)). Moreover, TBC and AA values presented an increase of 2.1, 2.0, 1.8, and 3.1 times compared to the initial values, with 745 mg GAE/100 g d.m., 256 mg CEQ/100 g d.m., and 102 mg C3G/100 g d.m., 1546, and 2130 µmol TE/100 g d.m. for total polyphenol, flavonoid, and anthocyanin contents, DPPH and FRAP assays, respectively. For efficiency, percentage of concentrate, and solute yield, the values were close to 86%, 81%, and 0.9 (kg/kg), respectively. Therefore, this research offers the opportunity to see aqueous herbal plant extracts as concentrated products with interesting quality properties, and in turn, the impact of this study is based on the concentration of a valuable medicinal herb plant with a non-thermal and innovative technology, and the future massive production for sustainable utilization in food, beverage, and pharmaceutical industries.

Food performances, properties, digestibility & functionalities

Poster

Processing and formulation modulate aroma, saponins and sensory profiles in pea-based cakes

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Legumes are receiving a huge momentum as interesting contributors to the food transition. Pea-based ingredients are increasingly used due to their interesting nutritional, functional and ecological characteristics. Yet the food industry is facing a challenge to introduce them into foods. This is due to several flavour compounds, inherent or induced by the process, which result in undesirable bitter taste and beany off-flavors. Despite the fact that from the sustainability standpoint the use of complete raw materials should be encouraged, there are still quality and nutrition issues for low-processed ingredients such as a higher presence of unpleasant odors, bitter and anti-nutritional compounds relatively to more refined ingredients such as protein isolates and starches. Therefore, this study aimed at understanding the impact of product processing and formulation on the fate of key aroma and taste compounds which are, in turn, linked to sensory perception.
For that purpose, different recipes of cakes were formulated by varying the composition of the pea ingredients (whole pea flour or its sub-fractions, starch and protein isolate) and the process parameters (beating time and baking temperature). The sensory properties of the cakes were characterized by descriptive quantitative analysis with 12 trained panellists. Chemical profiles of the main aroma compounds were analysed by HS-SPME/GC-MS and GC-Olfactometry to identify the changes in the key odour-active compounds. A kinetic approach was also carried on cakes to determine the fate of saponins during processing by an original method using HPLC-HRMS-ToF. Our results show the marked influence of formulation type and heat treatment on the sensory, volatiles and saponins profiles of the cakes. Longer beating times correlated with rancid, fatty and green odours and flavour perceived attributes, and enhanced lipid oxidation. More intense baking conditions led to the development of nutty and roasty notes and the decrease of the lipid oxidation notes. On the other side, the thermal degradation of saponins was also highlighted and quantified during baking. These results will be discussed in the light of chemical changes during processing and will provide insight into the links between sensory perception and flavour determinants which are key quality markers of these emerging ingredients.

Food performances, properties, digestibility & functionalities

Poster

The usefulness of the extrusion technique as a quantitative measure of differentiating dysphagia-oriented meals based on particle size disparities.

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The particle size is the key consideration when designing International Dysphagia Diet Standardization Initiative (IDDSI) Levels 4 and 5 meals. The particle size requirement for IDDSI Level 5 is 4mm × 15mm to ensure swallowing safety and to provide distinct texture. Currently, the particle size is routinely evaluated through the slot between fork prongs. The gap between the prongs of a standard dinner fork measures 4mm, while the length of four prongs is about 15mm, which provides the rationale for using a fork to measure the particle size. IDDSI test methods provide useful clinical compliance checks for particle size and work well in smaller kitchens. However, they are slow and difficult to use in a commercial setting where quality checking of massive production would be challenging. Moreover, Fork measurements do not provide precise quantitative comparisons across products. Product comparison is crucial during product development to achieve more accurate and consistent outcomes. Therefore, the purpose of the current study was to develop an in-plant technique that can distinguish products based on particle size differences. We developed the technique – "Extrusion" to see if this technique could differentiate products based on particle size differences. The hypothesis is that the force needed to extrude the sample would reflect the food particle size. Extrusion test results were compared with the IDDSI particle size and sieve test measurements to find if they produced compatible results. The extrusion test generated unique force-displacement graphs for each product that distinguishes one product from another based on the particle size disparities. Each graph provided quantitative information about particle size by visually representing them as peaks with different magnitudes on a force-displacement graph. The average extrusion force and the average force fluctuation from the mean force were statistically significantly different ($p<0.05$) between IDDSI Levels 4 and 5. Results were also compatible with the IDDSI test and sieve test results. Therefore, the author would like to propose this technique as a reliable in-plant quality control tool that provides useful guidelines for texture-modified food manufacturers to differentiate their products based on particle size disparities.

Poster

Study of a post-column synchronous fluorescence derivatization to analyze phytates in foods by chromatography

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Phytates (myo-inositol-1,2,3,4,5,6-hexakisphosphate or InsP6) is the storage form of about 80% of total phosphorus in foods. They are commonly referred to antinutritional compounds because they strongly chelate with divalent cations such as iron, potassium, calcium, magnesium, zinc and copper, impeding their absorption. Their nutritional effects and physiological functions are dependent on the number and the position of the phosphate groups on the myo-inositol ring ($InsP_{1\ to\ 6}$). However, the lack of analysis method accurate and reliable to quantify each form creates the need to develop new approaches.

In this study, a chromatographic methodology (HPLC) was developed and enhanced to separate and quantify the six forms of myo-inositol polyphosphates using synchronous fluorescence by post-column derivatization. Maximization of reagents content and assays were realized in static and dynamic step, and standards were bought pure from Larodan (USA). The HPLC (Agilent infinity II – Fluorescence/Diode Array Detectors) was improved with a supplementary pump for post-column derivatization through a knitted open tubular (KOT) reactor.

Results indicated that this innovative method crossing HPLC and synchronous fluorescence of iron-phenanthroline (0.0045 mol/L $FeCl_3 \cdot 6H_2O$: 0.0085 mol/L phenanthroline) with a post-column derivatization is promising and fast for phytates separation and quantification. Indeed, the quenching of phenanthroline caused by the presence of iron was canceled when InsP eluted through a separation by ion-pair reverse chromatography (44% 0.035M formic acid mixed with 56% methanol and 1% tetrabutylammonium hydroxide fixed at pH 4.3 adjusted with H_2SO_4 72%). It allowed an increase of the detection limits of InsP compare to conventional refractometer (RID). It seemed that using the same phase for InsP extraction could simplify the process route by avoiding unitary operations such as evaporation, purification or concentration compared to classical extraction. Methanol fraction contained in the solvent might be able to slow or stop enzymatic and non-enzymatic hydrolyses of InsP during extraction, stabilizing the extract environment too.

This innovative analytical approach to separate and quantify phytates by HPLC seemed robust and reliable. Additional assays need to be performed to determine the applicability of the method in multiple food environment and evaluate phytate subsequent impact on divalent minerals' bioavailability.

Poster

Study of a Complex Peanut-Based Matrix Structuration Through Gelation Processes

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The peanut (Arachis Hypogaea) is a legume widely consumed in developing countries across Africa, Asia and South America. Peanut are rich in fat protein and carbohydrate and may be a good raw materiel for food formulation through functional properties of proteins.

Objective : The general aim of this study is to determine gelation ability and physical structuration of raw peanut suspensions taken into consideration the contribution of the different phases (soluble protein and oil and insoluble dispersed phases).

Methods : Suspensions composed of grinded white peanut mixed with salted water were prepared and characterized. The peanut proteins were then extracted to assess their gelation properties under different physical and biochemical processes. Heat treatments were performed on protein extract with or without previous enzymatic treatment with transglutaminase. The gels' structural properties were assessed by rheology and confocal microscopy.

Results : Different gel structures could be obtained depending on the protein extraction conditions and gelation process, i.e gels are more structured, yet weaker with a prior enzymatic treatment. Their viscoelastic properties are also dependent on the ionic strength during extraction and gelation. Dispersed fat tends to reinforced gel properties in the case of enzymatic pretreatment. Insoluble fractions allow to increase the viscoelastic properties of the gels in both conditions.

Conclusion : This study demonstrate the ability of peanut protein to gel, and the impact of insoluble part, and the capability to tailor the gel properties of raw peanut suspension through the gelation conditions.

Poster

Influence of nanocellulose with different particle size on pasting and rheological properties of wheat starch

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Tailored design of novel materials requires a huge understanding about structural properties, and how structures define functionality. Cellulose nanofibrils (CNF) and cellulose nanocrystals (CNC) have been described as biomaterials with wide applications in polymer science. However, their use in food science and nutrition, specifically designing food structures is scarce. This work aimed to investigate how CNF and CNC modify macrostructural features of wheat starch such as pasting and rheological properties.

CNF (Vuelo Pharma, Brazil) and CNC (UPC-UMaine, USA) were blended with wheat starch (Sigma-Aldrich, Germany). CNF and CNC were added at concentrations up to 10%w/w. Starch-CNF and starch-CNC blends were processed by Rapid-Visco-Analysis (RVA, 90°C/3min) and cooled to 25°C. Pasting parameters were assessed. After RVA, starch-nanocellulose pastes were characterized by rheology (25°C): dynamic frequency sweep (0.1-600rad/s), dynamic time sweep (4h) and in-shear recovery (100 1/s, 60s).

Previous analysis (AFM and DLS) allowed to assess particle size (120nm CNC, 4000nm CNF) and charge (-49mV CNC, 1.3mV CNF). Nanocellulose significantly modified the pasting properties, but strongly influenced by particle size. CNF significantly increased all pasting parameters of wheat paste, whereas CNC only slightly increased same parameters (e.g. final viscosity 1700cP, 2000cP and 4700cP in control starch, 10%CNC-starch and 10%CNF-starch, respectively). Rheology characterization showed that CNC and CNF produced a significant increase in G’, which was also proportional to nanocellulose concentration. However, values of loss factor (G’’/G’) suggest big structural differences addressed by particle size of nanocellulose. Loss factor values were lower in pastes CNC-starch, over the whole frequency range tested. The latter was confirmed by dynamic time sweep, which showed that CNC promoted the self-association of amylose detected from the faster increase in G’ and faster decrease in loss factor, which in turn approaches rapidly to values <0.1 depicting behavior as strong gels. The opposite was observed in CNF-starch, where G’ were lower than control in samples containing CNF. Loss factor of gels containing CNF reached values >0.1 depicting behavior as weak gels. Interestingly, in-shear recovery data showed that strong gels promoted by CNC has lower capacity of recovery with values around 57-62%, whilst weak gels containing CNF showed values of 80-67%.

Food performances, properties, digestibility & functionalities

Poster

Effect of soluble dietary fiber on microstructural changes, in vitro and in vivo starch digestibility in laminated dough and wheat bread

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The prevalence of diet-related chronic diseases such as type 2 diabetes encourages the design of starchy foods to control starch digestibility. The objective of this research was to understand the effect of soluble dietary fiber (SDF) addition in the structure of baked gluten-starch matrices and wheat bread, and analyze its effect during *in vitro* and *in vivo* starch digestibility, using a microstructural approach.
Inulin and polydextrose were firstly examined by adding them at different concentration (7.5 and 13%) in laminated gluten-starch model doughs, which were baked at 170°C.
Both SDFs showed a significant reduction in starch gelatinization, probably linked to a decrease in water activity in the dough (r=0.85). *In vitro* starch digestibility was reduced accordingly. The rapid available glucose (RAG) fraction decreased compared to the control, from 34.85 to 8.56 and to 15.13 g/100g, whereas the unavailable glucose (UG) fraction increased from 47.59 in the control sample to 87.76 and 76.27 g/100g, in matrices with 13% inulin or polydextrose, respectively. These results could be also linked to a reduced bioaccessibility due to starch granules coating, as revealed by FE-SEM and, also, to the lower porosity and higher compactness as quantified using X-ray microCT image analysis.
Accordingly, inulin was selected to be added to wheat bread formulation and was combined with modified cellulose fiber. The dough was processed following a standard industrial protocol for bread production. All samples showed a well-developed and continuous protein network with a good performance during breadmaking, as shown by FE-SEM micro-images. SDF-formulated bread showed a reduction in total porosity and pore diameter along with a slight increase in structure thickness, compared to regular bread, leading to a more homogeneous structure. *In vitro* assays revealed a decrease in RAG from 31.02 to 11.52 g/100g, and an increase in UG from 62.81 to 80.49 g/100g, in SDF-formulated bread compared to the control. These results were consistent with *in vivo* clinical trials (12 male volunteers), which showed a lower postprandial glycemic response in SDF-formulated bread and could be classified as slowly digestible since both the glycemic index (56.43) and the glycemic load (15.11) were in the intermediate range.

Food performances, properties, digestibility & functionalities

Poster

Physicochemical and pasting properties of two varieties of Andean amaranth (Amaranthus caudatus)

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Dietary guidelines recommend an increase in the consumption of whole grains due to their role in reducing the risk of chronic degenerative diseases. Andean grains are whole grains with many qualities as raw material to be transformed into functional foods. Amaranth (*Amaranthus caudatus*) is an Andean grain, which is endemic to Bolivia, Peru and Ecuador, mainly. The properties of raw materials largely depend on their chemical composition. The objective of this study was to evaluate the physicochemical and functional properties of two varieties of Andean amaranth, Tomina and Barbechos. Both varieties showed the following composition: protein 13.1 – 13.4, fat 8.08 – 9.50, ash 2.64 – 2.83, crude fiber 3.83 – 4.07, carbohydrates 72.6 – 70.0 and starch 64.7 – 62.8 g/100g for Tomina and Barbechos, respectively. Amaranth starch was characterized by the absence of amylose. The pasting properties were evaluated, the pasting temperature (PT) was from 61.8 to 65.2°C, the peak viscosity (PV) was from1054 to 1178 cP, the holding strength (HS) was from 592 to 574, the breakdown (BD) from 462 to 603 cP and the final viscosity (FV) from 955 to 941 cP for Tomina and Barbechos, respectively. The solubility increased around 75°C. The proximal analysis had slight differences in fat and crude fiber content. However, the amylase-lipid complex formed by the thermal process may not exist due to the absence of amylose and the fat may be more accessible in the final products. Pasting properties were related to the absence of amylose with low values ??for SB and BD. The structure of amaranth grains, absence of amylose and high swelling power, indicates that it is suitable for use in food applications, under heat or cold thermal processes or texture improver, as well as non-food uses. The information obtained in this study could be useful for the food and related industries that make use of amaranth or amaranth starch.
Keywords: whole grain, amaranth, Andean, starch and amylose.

Food performances, properties, digestibility & functionalities

Poster

Can storage stability of citrus fiber powder be explained by modifications of their physicochemical properties?

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Citrus, consisting of orange, lemon, mandarin, and grapefruit, is the most important crop in the world, with worldwide production of 144 million tons in 2019. Most of the fruits produced are used for juice production, pectin, and flavonoid extraction, which results in a huge quantity of by-products corresponding to 50-60% of the original whole fruit weight. Biopolymers are the main constituents of these agro-industrial wastes and present many properties that make them interesting for applications such as sustainability, inexpensive, biodegradability, friendly to the environment, and recyclability. Citrus fiber powders (CFP), manufactured from pectin extraction of lemon juice industry by-products, are characterized by an ability to retain moisture and good emulsifying stability and could have many food applications in baked products, meats, dairy products, sauces, and dressings. The fibers are dried to facilitate distribution and commercialization as a food ingredient. The quality of the dehydrated powder is influenced by the processing and storage condition. However, the mechanism of the modifications induced by storage on functional properties of the powders and especially rehydration properties were not understood. This study aimed at investigating the mechanisms responsible for CFP stability upon storage. Samples were stored in different conditions of temperature and humidity for 12 months. Gelation, water holding capacity, and swelling capacity were used to evaluate the effect of storage on functional properties. In addition, powder surface composition, morphology, and chemical and physical properties were analyzed to understand the modification of physicochemical properties during storage. The results highlighted that properties related to moisture retention, emulsifying stability, and rehydration decreased with increasing aging time. The loss in functionality was accelerated at 40 °C and 75%RH compared to 25 °C and 30% RH. These modifications might be linked to the chemical structure of the biopolymers further than to surface composition and morphology.

Poster

Water sorption properties of malt bagasse as essential information for byproduct stabilization and further conversion into high value-added materials

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Brewer's spent grain (BSG) has showed growing interest as a sustainable source of plant-based proteins, but also serving as raw material for second generation bioethanol production – both applications aiming at the circular economy. However, because it presents high water activity at the end of the brewery processing, the determination of its water sorption isotherms and thermodynamic properties becomes necessary under simulated storage and drying conditions. Firstly, BSG were chemically characterized to be, then, subjected to the static gravimetric method in order to experimentally obtain the water adsorption isotherms at ten temperatures (5–90 °C). BSG showed high contents of proteins (>21.4%) and fermentable matter (>44%), confirming the initial applications purposes. Once the sorption isotherms were determined, the Guggenheim-Anderson de-Boer (GAB) model could be adequately fitted to the experimental data (R2adj>0.9928 e Chi-square≤0.0001). At temperatures from 5 to 50 °C (storage conditions), the adsorption isotherms showed convex curves, typical of type III isotherms. However, at temperatures above 60 °C, the curves tended to present shapes typical of type II isotherms, with sigmoidal sorption behavior. In both situations, the equilibrium moisture content (0.0236-0.7648 g of water per·g of dry matter) increased with increasing the relative humidity (0.0520-0.9848) and/or decreasing temperature. When analyzing the thermodynamic properties, the net isosteric heat of adsorption (140.88 to 3303.56 J·mol-1), differential enthalpy (-140.88 to -3303.56 J·mol-1), and differential entropy (0.01 to 7.59 J·mol-1·K-1) decreased as the equilibrium moisture increased. The compensation theory was confirmed through the linear relationship between enthalpy and entropy, indicating that the adsorption processes of the BSG were governed by enthalpy. The positive value for Gibbs free energy (199.37 J·mol-1) indicated that the adsorption processes were not spontaneous. From an energetic and stability point of view, a relative humidity of 40% was considered the ideal condition for the storage of BSG. With the obtained information, the drying and storage conditions of wet BSG can be more adequately designed to produce stabilized raw materials for different further applications.(Funder: FAPESP - Grant 2022/05272-8).

Poster

Production of hybrid microparticulated proteins based on whey protein and pea protein at different pH values

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OBJECTIVE
The aim of this work is to manufacture hybrid microparticulate proteins based on whey protein concentrate (WPC80%) and pea protein at three different pH values.

METHODS
For the study, three different treatments were produced in which the pH of the microparticulation process was modified: T1 (pH=4.0); T2 (pH=5.5); T3 (pH=6.7). The microparticulation process was carried out by mixing 36.80 g WPC80%, 58.03 g pea protein, 25.17 g whey permeate. Then the powders were added in 852.22 g of water by stirring for 1 hour and stored at 8±2 °C for 24 hours. After this time the sample was homogenized and added 27.77 g of a 40% (m.v-1) $CaCl_2$ solution and the pH was adjusted for each treatment using lactic acid and 50% (m.v-1) sodium hydroxide. After pH adjustment each sample was heated to 95 °C for 10 minutes and stirred at 3100 rpm. Finally, the heating was turned off and the stirring was raised to 10000 rpm, the pH was adjusted to 6.5 at the end of the process. To verify the microparticulation process of the product, particle size analysis was performed.

RESULTS
After the homogenization process, the treatment T1 presented a particle size of 10.09±0.05 µm, T2 of 9.81±0.08 µm and T3 of 9.57±0.04 µm. With the addition of $CaCl_2$, pH adjustment and heating to 95°C the particle sizes changed to: 21.75±0.33 µm for T1, 14.67±0.03 µm for T2 and 23.9±0.08 µm for T3, demonstrating that the pH of the solution modifies the denaturation of proteins present in the mixture. After shearing and final pH adjustment the particle sizes observed were 9.06±0.03 µm for T1, 8.10±0.08 µm for T2, and 7.90±0.07 µm for T3.

CONCLUSIONS
It was possible to develop microparticulated proteins from whey and pea proteins, in addition the study also demonstrated that the pH of the microparticulation process has a relationship with the particle size at the end of the process, and in the lower pH studied showed larger particle size.

Poster

Use of microparticulate whey proteins in the production of Dulce de Leche

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OBJECTIVE
The objective of this work is the production of dulce de leche with added microparticulate whey protein (MWP) as a partial milk replacer in the manufacture of dulce de leche, with the intention of reducing the fat content of the product and improving its functional characteristics.

METHODS
Microparticulation: 122.62 g of WPC80% and 77.38 g of whey permeate were weighed, both supplied by the company Sooro Renner Nutrição S.A. (Brazil), these powders were mixed and added to 753.73 g of water and stirred for 1 hour, then stored at 8 ± 2 °C for 24 hours. After this time, 46.27 g of a 40% (m.v-1) $CaCl_2$ solution was added. The pH of the solution was adjusted to 4.0 using lactic acid. The mixture was heated to 95 °C for 10 minutes stirring at 3100 rpm. Finally, the heating was turned off and the stirring was increased to 10000 rpm, and the pH was adjusted to 6.5 at the end of the process. To ensure that microparticulation of the product occurred, particle size analysis was performed.
Production of dulce de leche: Dulce de leche was produced with different proportions of milk substitution for MWP. The final point of the dulce de leche was obtained by mass balance and soluble solids content. After production, compositional analyses of the product and also rheological analyses were performed, with the purpose of studying how the replacement of milk by MWP could modify the rheology and the final composition of the product.

RESULTS
The dulce de leche produced with different proportions of milk substitution by MWP showed different texture and viscosity than the control product, and the color observed in the products is also different. Another interesting result is that there is a reduction in the fat content and an increase in the protein content of the product as the milk replacement by MWPs increases.

CONCLUSIONS
With this work it was possible to conclude that it is possible to produce dulce de leche with reduced fat content and increased protein content using microparticulated whey proteins.

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Food performances, properties, digestibility & functionalities

Poster

Oxidative Stability of Encapsulated Fish Oil by Non-purified Soy-Lecithin and Dextrose

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Objective:
The main objective of this study was to assess the oxidative stability of encapsulated fish oil within a complex produced by the reaction of non-purified de-oiled soy lecithin and dextrose following a Maillard reaction path. The effects of formulation and processing conditions, notably temperature and time, on the rancidity of the encapsulated PUFAs were studied.

Methods:
As stated in a patented technology (international application number PCT/US21/65358), de-oiled crude lecithin (40 or 44%) is mixed with fish oil (32%) and then, dextrose solution (20% water and 4 or 8% dextrose) is added to the mixture. The mixture is subjected to the heat at 80 ? C or 100 ? C for an hour to facilitate Maillard Reaction and vacuum-dried for 24 hours. No heat treatment (NHT) samples were used as a control group. To characterize the encapsulated oil particles, moisture content, water activity, encapsulation efficiency-EE and oxidative stability (peroxide value-PV and p-anisidine-pAV value) every 10 d over 90 d testing period at ±25?C were measured.

Results:
Results showed that microcapsules containing 40% oil content exhibited 50-70% encapsulation efficiency, viscosity of 0.6 Pa.s, low moisture content (<1%), and low water activity (<0.7).
After 90 days storage, the encapsulated fish oil particles remained within the rancidity limits of PV of 10-30 mEq/kg oil and pAV <20; however, unprotected fish oil exceeds these limits. Maillard Reaction products (MRPs) were also assessed in the encapsulating wall material, and Amadori-PE (Phosphatidylethanolamine) products, are known as predictive markers for phospholipid glycation in food systems, were mostly detected.

Conclusions:
De-oiled crude soy lecithin reacted with dextrose under appropriate conditions to perform a controlled Maillard reaction resulted in a complex which was able to encapsulate fish oil (40%) to be protected from oxidation, providing longer shelf life. The existence of a complex with the capacity to produce microcapsules protecting fish oil is reported for the first time, and the study shows the novelty of using glycated phospholipids as an encapsulating carrier. Besides, the utilization of crude lecithin, a byproduct of edible oil processing, makes the proposed technology sustainable and inexpensive.

Poster

Deep Learning and Chemometrics Aided Development of a Virtual Hyperspectral Imaging and Quality Assessment of Plant Proteins

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The food industry is seeing considerable growth in demand for plant-based protein products. This study aims to develop virtual hyperspectral imaging (VHSI) by using deep learning methods to reconstruct hyperspectral images from RGB images and using the develop VHSI to assess the quality of pea proteins. Near-infrared HSI (900 – 1700 nm) was used to capture images of pea proteins. A smartphone camera was also used to capture the images of the same samples under different illumination scenes. The acquired hyperspectral images were preprocessed using different spectral preprocessing methods to augment the data. A deep learning model was used to convert the RGB images to hyperspectral images with multiple bands across the NIR spectral range. Chemometrics or machine learning methods were applied to develop predictive models for predicting pea protein quality attributes. Results of the study show that hyperspectral images were accurately reconstructed from RGB images. It also shows that the reconstructed images accurately predicted pea protein quality properties. The findings indicate that the development of an alternative approach to measuring food quality based on the developed VHSI would have wide application as a low-cost device for at-line, in-line, and on-line food quality control and traceability.

Poster

Effect of pH on the gelling properties of pea protein-pectin composite gels

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Objective:
Investigate the combined effects of pH (5.5, 7, 8.5) and addition of pectin (0.5% and 1%) on the rheological properties and microstructures of pea protein gels.
Methods:
The physicochemical characteristics of pea protein-pectin dispersions at different pH were investigated, including particle size, zeta-potential, solubility, and phase separation behaviors. Pea protein-pectin interactions as function of pH were analyzed by a Quartz crystal microbalance with dissipation monitoring (QCM-D). The viscoelastic properties of samples were monitored during the whole gelation process and determined by rheology. Confocal laser scanning microscopy (CLSM) was used to observe gel microstructures changes. The in vitro digestibility of gel samples was also investigated.
Results:
At pH 5.5, the addition of pectin significantly increased the size of protein aggregates, which could be explained by the relative strong electrostatic attractions between pea proteins and pectins, revealed by QCM-D, leading to the formation of insoluble complexes and reduced soluble protein contents. During gelation, the association of unfolded proteins facilitated the connectivity of aggregates, resulting in the formation of coarse and particulate gel networks with increased storage modulus. However, larger aggregates formed in the presence of 1% of pectin weakened the gel strength. At pH's 7 and 8.5, the addition of pectin also increased the particle size of protein aggregates mainly due to phase separation of incompatible biopolymers since pea proteins and pectins were negatively charged. The excluded volume effect induced by phase separation increased the local concentration of proteins and promoted the formation of large aggregates, resulting in increased storage modulus of pea protein-pectin composite gels after gelation. Phase-separated gel structures were also found under confocal microscopy showing a protein continuous network and pectin occupying the void spaces. Furthermore, the addition of pectin revealed an increase of protein degradation extent under simulated gastrointestinal conditions at all pH values.
Conclusions:
The pH value and pectin concentration showed a significant impact on the mechanical strength and microstructures of pea protein gels, which could be ascribed to the different interaction modes of protein and pectin. By varying pH and pectin concentrations, novel pea protein-based gels with various mechanical properties and microstructures could be designed.

Food performances, properties, digestibility & functionalities

Poster

In vitro protein digestibility of meat analogues made of sunflower and pea protein

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Global growing demand for meat and meat products has negative environmental impact such as increased greenhouse gas emissions, water, and energy consumption. Therefore, there is a need for sustainable plant-based foods alternative to animal counterparts. From a nutritional perspective, it is important to elucidate the processing induced effects on protein digestibility. However, there is limited knowledge on protein digestibility of meat analogues.
The aim of this study was to investigate the protein digestibility of plant-based meat analogues made with high-moisture extrusion from sunflower protein concentrate (SPC), pea protein isolate (PPI), fermented SPC and their mixtures. Protein digestibility was studied in vitro with the INFOGEST method, which mimics the physiological conditions in the oral and gastrointestinal phases of the digestion process. Digestibility was assessed by analysing the degree of protein hydrolysis (DH) after digestion with the OPA-method. The results of the extrudates were compared with those obtained with the corresponding powdered raw materials. The degree of protein hydrolysis of the samples ranged from 11 % to 53 %. Overall, powder samples showed similar protein digestibility, although slight differences were observed between PPI (34% DH), SPC (33% DH) and a 1:1 mixture of SPC and PPI (28% DH). The extrusion process showed improved results in protein digestibility compared to powder samples, with extruded SPC exhibiting 53% DH and extruded SPC and PPI blend (1:1) 39% DH. Fermentation of SPC powder increased the DH from 33% to 43%, indicating that application of fermentation process can have positive impacts on protein digestibility. However, when the fermented SPC was used in extrudates together with PPI (1:1), no change in digestibility was observed as compared with extrudates in which non-fermented SPC was used together with PPI (1:1).

Poster

THE IMPACT OF CAPSICUM OLEORESIN-LOADED MICROPARTICLES ON THE LIPID METABOLISM, GLUCOSE LEVEL AND SATIETY HORMONES IN MICE

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Capsicum oleoresin is a food flavoring agent and source of capsaicin, compound responsible for health benefits. In this work, the effect of Capsicum oleoresin (CO) microparticles on glucose tolerance, lipid metabolism and leptin levels were investigated in diet-induced obese mice. Emulsions were formulated with gum arabic and modified malt as emulsifying agents. Two formulas containing 15% solids were prepared with 5% CO and 95% emulsifier (F1), and the second formula (F2) containing 2.5% corn oil plus 2.5% of CO and 95% emulsifier (F2). Rotor-stator homogenized these formulas (5000 rpm/10 min), and they were atomized in the spray dryer. Ultra-Performance Liquid Chromatography determined the capsaicin content for all formulations. Mice were divided into two groups: lean control (norm caloric AIN diet, n=10) and fat (HF diet: hypercaloric, n=30), which were subdivided into three subgroups, as follows: HF control diet (n=10), diet F1: HF + 20% CO oleoresin microparticles (n=10) and diet F2: HF + 20% CO microparticles with corn oil (n=10). As a result, animal groups received a high-fat diet containing 0.0044% (F1) and 0.0028% (F2) of capsaicin daily. The animals in the group treated with the microparticles showed lower glucose levels compared to the group fed only with HF control. Mice fed with HF containing CO microparticles showed cholesterol blood levels like lean group and lower (<100 mg/dl) than animals fed with high-fat diet (150 mg/dl). The liver's total lipids, cholesterol, and triglycerides were also lower for the groups treated with the microparticles. Leptin levels for mice fed with high-fat diet plus CO microparticles showed an average of 2-5 ng/ml, whereas dosed values above group 10 ng/dl characterize leptin resistance in the high-fat control group. Capsicum microparticles evidenced a protective effect against dyslipidemia compared to the fat control group, which makes it a potential ingredient to induce satiety and obesity control.

Food performances, properties, digestibility & functionalities

Oral

In vitro starch and protein digestibility of legume enriched biscuits using static and Dynamic Duodenal Model

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Introduction

In vitro digestion models provide information regarding nutrient digestibility and can predict human metabolic response.In the present study in-vitro digestion of the main macronutrients of two legume-enriched wheat biscuits and a wheat biscuit was performed. The legume-enriched biscuits differ in their amino-acid composition, because they were formulated with different mixtures of legumes and seed flours, but they have same protein quantity.The aim of the study was to examine the influence of biscuits' composition in the digestibility of protein and starch.

Methods

Legume-enriched biscuits consisted of 14 and 14.5% protein, 36.2 and 36% starch.Wheat control contained 7,9% protein, 44.9% starch.All biscuits had similar sugar and lipid content of 10-11% and14-14,5%.The static protein digestion was adapted from INFOGEST2.0. In-vitro starch digestibility was determined with simulation of the intestinal phase. Digestion was also done with the Dynamic Duodenal Model (DDM) which mimics intestinal motility. Proteins and reducing sugars Determination was performed with Bradford Assay and DNS method, respectively.

Results

No statistically significant differences on protein digestion were observed between the samples. Static digestion of wheat and legume-enriched biscuits resulted in about 14% hydrolysed protein at the gastric and 60% after 120 minutes of intestinal digestion. In the DDM about 33% of the protein was digested for all biscuits.Starch digestion indicated that 8-14% of starch was hydrolysed.The three biscuit samples showed similar starch digestibility during Dynamic digestion, with 35-40% of total starch being hydrolysed at the end of the intestinal phase. It must be noted that non-reducing sugars, such as sucrose, cannot be determined byDNS Method.This method's limitation leads to the underestimation of total hydrolysed starch and may have affected the results.

Conclusions

The proteins of all three biscuits in static model showed similar digestion profiles and are mainly hydrolysed in the intestinal phase. Both starch digestion models yielded similar starch hydrolysis curves between the different samples. Static and dynamic models seem to provide different quantities of final hydrolysed nutrients but similar digestion profiles. Starch and protein digestibility under investigated conditions seemed to be unaffected by the biscuit formulation. However, in an in-vivo study consumption of these biscuits can cause different metabolic responses.

Poster

Plant-based 3 printed meat analog based on chickpea protein isolates, alginate, and Spirulina biomass

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There has been growing interests in the development of novel foods based on sustainable echo-friendly proteins. In this study, the formulation for 3D- printing of a meat analog based on chickpea and microalgae biomass were studied. The results showed that the optimal conditions for concentration of calcium chloride in solution, the residence time of the meat substitute sample in calcium chloride solution and the spirulina protein substitution were 1% (w / v), 3 hours and 2% (w / v), respectively. Three samples coded as M1 (meat substitute based on chickpea and rice protein), M2 (meat substitute based on chickpea and rice protein with 0.8% beet root extract) and M3 (meat substitute based on pea protein, rice and Spirulina with 0.8% beet root extract) using a 3D printer (print speed 0.03 mL / min, nozzle size 1 mm, syringe volume of 20 mL, nozzle height 1.8 mm, and layer height equal to 1.7 mm) were produced. The results showed that by applying these changes in the formulation, the elongation at break (%) (from 50 to 53 and then 60%), tensile strength (MPa) (from 2.18 to 2.71 and then to 52.5 2), the breaking time (s) (from 16 to 17 and finally to 18) increased, indicating an increase in the elasticity of the meat substitute samples. These changes, along with the increase in scores obtained from sensory evaluation, indicated an increase in the desirability of meat analog samples (M2 and M3) compared to the M1 sample. In addition, it was found that spirulina protein substitution did not result in significant changes in the physicochemical properties of the sample, such as pH, moisture, and ash. The results of this study show that the proposed formulation, in addition to increasing environmental sustainability, led to the production of desirable meat analog.

Food performances, properties, digestibility & functionalities

Poster

Rheological investigation through 3D printed omega-3 rich analogue meat using grass pea and microalgae biomass

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In this study, a 3D printed plant protein-based meat analogue was formulated using a blend of grass pea protein, starch, and microalgae cells. Protein concentrates from *Lathyrus Sativus* and *Lathyrus Rotundifolius* were extracted by an alkaline method and the chemical, rheological and functional properties of the proteins were investigated. *Nannochloropsis ocenica* was cultivated on nanofiltered acid whey permeate to form omega-3 rich cells. Then the microalgae cells and protein concentrate were used for the formulation of an ink for 3D printing. Meat analogue samples were printed using a 3D printer equipped with a syringe pump. The textured product was fabricated based on blends of 6 % protein, 14 % starch, and 1 % microalgae biomass by a heating-cooling cycle followed by 3D printing. Both grains provided high amounts of proteins with acceptable functional properties, i.e. 12 % gelation concentration and high sulphuric amino acid content. Rheological investigations revealed that the ink was Newtonian initially, while a gel structure was formed upon heating and cooling. *L. Sativus* exhibited higher viscosity values during gelation. Texture analysis of the printed product revealed that the hardness of the 3D printed product was decreased in comparison with the moulded gels. Incorporation of microalgae cells decreased the hardness significantly while the stickiness was increased. In conclusion, the application of grass pea protein in combination with microalgae biomass can be regarded promising for the formulation of 3D printed analogue meat.

Poster

Influence of micro and nanofibrillated cellulose on yogurt production and storage

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OBJECTIVE

This work aimed to evaluate the effect of adding three hydrocolloids in the form of a vegetable cellulose colloidal suspension on the physicochemical characteristics of yogurts during production and storage.

METHODS

Three different cellulose fibrillated were produced, using bleached eucalyptus kraft pulp as initial substrate: (i) cellulose nanofibrillated (CNF) and (ii) microfibrillated cellulose (MFC) were isolated exclusive by mechanical defibrillation using disc ultra-refiner and (iii) enzymatic cellulose nanofibrillated (Enzy-CNF) was a combination of mechanical defibrillation and enzymatic post treatment of CNF. Four formulations of yogurts containing 9%w/w sucrose 81%w/w milk were prepared: T1= 10%w/w water (control); T2= 10%w/w MFC; T3= 10%w/w CNF and T4=10%w/w Enzy-CNF. Parameters such as acidity, pH, syneresis, consistency, particle size distribution and scanning electron microscopy were analyzed after 1, 15, 30 and 60 days after production, the fermentation curve was also monitored.

RESULTS

The profile of the yogurt fermentation curves, titratable acidity and pH during storage showed no significant differences ($p<0.05$) for the four treatments. The consistency measurement after 1 day of production showed that T1 reached the lowest values (represented by the highest flow distance), followed consecutively by: T4, T3 and T2. The applied statistics indicate that the result obtained by T1 was significantly different from the other treatments for $p<0.05$. The results of syneresis for the yogurt samples showed that T2, T3 and T4 presented less syneresis ($p<0.05$) in the evaluation at 15 days. Observing the evolution of particle size, at d90 it is possible to note significant difference ($p<0.05$) between the initial analysis and the other times only for T1, indicating an initial stability to the particle size in treatments T2, T3 and T4. The images of the microstructures of the yogurt gels show that formulations T2, T3 and T4 have a more heterogeneous protein network compared to the control yogurt.

CONCLUSIONS

The addition of cellulose colloidal suspensions to yogurt contributed positively to consistency and syneresis. Scanning electron microscopy showed that the yogurts that received the addition of these hydrocolloids presented a more heterogeneous and compact protein network than the control yogurt. Physicochemical parameters such as pH and acidity were not affected.

Poster

Exploring physicochemical and textural characteristics of Greek commercial pita breads

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Pita bread is a type of yeast-leavened flatbreadcommonly consumedin Greece. One of the quality requirements for this type of bread is to have a soft and flexible texture in order to be easily wrapped. The objective of this work is to monitorthe physicochemical and textural properties of commercial pitabreads, sold at ambient conditions.
A total of thirteen (13) pitabread samples from different producers were collected from supermarkets in Greece. Samples were stored in sealed containers at room temperature before being tested and handled based on manufacturers' instructions. First, there were heated (baked) and then allowed to reach room temperature before measuring their moisture, weight and volume, and testing their texture. A Kramer test was used to test the texture and Hardness and Work were calculated based on the curve obtained in the Texture Analyzer. Moisture and texture were also tested after storage of two and five days of the ready to eat pita breads.
In general, there were observed significant differences among the pitabreads in terms of specific volume, moisture and texture parameters. Both hardness and work increase with ageing whereas moisture content of pitabreads decreases. No correlation was observed between texture parameters with the specific volume but it was negatively correlated with the carbohydrate content ($r>0.57$) of the breads. Only work was significantlypositively correlated with the moisture ($r=0.67$) of the breads.PCA analysis revealed a clear separation of commercial pitabreads by the type of additives.
These preliminary results revealed that commercial pita breads vary largely in their physiochemical and textural properties. Parameters such as moisture and carbohydrate content but also type of additive seem to determine their textural properties.

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Poster

Effect of einkorn bran sourdough on physicochemical and technological properties of einkorn pita bread

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This study evaluated the effect of sourdough made from spontaneously fermented einkorn bran on the flatbread quality (pita bread) and aimed to combine the advantages of both presence of LAB with that of whole-meal einkorn flour.
Sourdough was prepared using einkorn bran (Greek var Kaploutzas) as a starter, distilled water and whole-meal einkorn to obtain a final dough yield of 170. The sourdough was freeze-dried and used in the bread recipe at levels 0 (control-1), 5, 15, and 20%. In addition, another control pita bread (control-2) was prepared using commercial yeast (1.5%) as the leavening agent. The effect of sourdough addition on specific volume, crust colour, moisture and texture of the pita breads was monitored. Texture and moisture of the pita breads were analyzed during storage (4°C).
Pita breads with sourdough did not differ in their specific volume compared to control-1 but showed significantly lower volume than control-2. All breads showed higher hardness than control-2 bread after 24h of storage whereas control-1 showed the highest springiness and lower moisture content among the samples. Hardness was increased with storage whereas springiness and moisture content was decreased. The highest moisture loss rate was observed in control-1. Hardness was negatively correlated with specific bread volume whereas springiness was positively correlated. Springiness was found to be negatively correlated with the moisture content in all samples. The present findings suggested that the addition of sourdough affected not only the moisture content but also the texture and colour parameters of pita bread.

Acknowledgment: The work is supported by the PRIMA program under grant agreement No. 2031, project Flat Bread of Mediterranean area: INnovation& Emerging process & technology (Flat Bread Mine). The PRIMA program is an Art.185 initiative supported and funded under Horizon 2020, the European Union's Framework Programme for Research and Innovation. The results and content found on this paper reflects only the author's view. The PRIMA Foundation is not responsible for any use that may be made of the information it contains.

Food performances, properties, digestibility & functionalities

Poster

Development of a tool to imitate the fork method described by the International Dysphagia Diet Standardisation Initiative

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Dysphagia is a condition defined by the difficulty in chewing and swallowing foods, which can be associated with malnutrition, dehydration, chest infection, and potential risk of death. The International Dysphagia Diet Standardisation Initiative (IDDSI) developed standard methods intended to be simple to classify foods and beverages into different levels, which are related with the different needs of patients. Although interesting, those methods lack scientific data and reproducibility. This work develops a probe to be coupled in a texturometer to perform the IDDSI fork test. The probe was designed to hold and press on the fork, imitating the thumb in the original test. The probe was designed in CAD and cut in aluminum sheets by a CNC machine, being then assembled. The fork was fixed to the probe, and the force required to make the thumbnail white was measured using a scale (490 gf = 4.8 N), being used for compressions. Four kinds of foods with different textures were analyzed: boiled potato (25 min cooking), carrot (30 min cooking), banana, and corn starch gel, cut into cubes of 1.5 cm side. With the maximum force set, the fork could entirely penetrate only the starch gel sample, penetrating only 2.69 mm of potato, 2.63 mm of carrot, and 4.8 mm of banana. The energy required for the fork penetrating those depth into the samples was 28 mJ for potato, 27 mJ for carrot, 32 mJ for banana, and 45 mJ for starch gel. Only the starch gel could be classified as soft and bite-sized according to the IDDSI, once the other foods could not be compressed using this force. The results using the developed probe agreed with the standard IDDSI method. The developed instrument proved to be efficient in imitating the fork test proposed by the IDDSI, turning the current qualitative analysis as quantitative. Moreover, the food can be compressed with the same force pattern, which guarantees greater precision in the analysis and study of data since the test conditions can be controlled instrumentally.
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Food performances, properties, digestibility & functionalities

Poster

An ICP-OES approach for macro-element profiling of legume species conventionally grown in Serbia

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Keywords: macro-elements, legumes, microwave digestion, ICP-OES, MANOVA,

In this study, macro-element profiles were determined in the following major legume species: common beans (Phaseolus spp; n=17), faba beans (Vicia spp; n=8), field peas (Pisum spp; n=7) and grass peas (Lathirys spp; n=6). Samples were cultivated conventionally at the Institute of Field and Vegetable Crops in Serbia, in 2019. They were milled into flour and digested in a microwave oven, following a slightly modified and shortened method compared to the standard method for cereal grains, as provided by the manufacturer. About 0.5 g (± 2%) of each flour sample was put in a teflon vessel, where 5 ml of 65%nitric acid and 2 ml of 30%hydrogen peroxide were added. The microwave power used was 800 W, with a total digestion time of 40 minutes, with additional 20 minutes for cooling down the sample vessels to room temperature. The clear liquid, obtained after sample digestion, was diluted with 2% nitric acid and put in a glassy vial till analysis on an ICP-OES device, for macro-elements: phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). All samples were analyzed in triplicate. Summary statistics, MANOVA and PCA were performed using the SPSS 26.0 software. The mean contents of P, K, Ca and Mg, respectively, were as follows: 4003.7, 14177.4,1400.0 and 1280.0 in mg/kg of common bean; 3389.7, 13679.4, 1004.1 and 1164.4 in mg/kg of faba bean; 2309.3, 8980.7, 938.4 and 961.8 in mg/kg of field peas; and 4324.2, 11743.3, 1004.7 and 1139.5 in mg/kg of grass peas flour. MANOVA revealed significant differences between common beans and field peas in P, K, Ca and Mg contents; between field and grass peas in P and K contents; and between faba beans and field peas in K content. The P content was the highest in grass peas, and the K, Ca and Mg in common beans. According to the literature, legume grains are high in calcium and magnesium, compared to the cereals, indicating these crops could provide a nutritional balance. In addition, while potassium needs could easily be met in daily nutrition, legumes are considered an important source of phosphporus.

Food performances, properties, digestibility & functionalities

Poster

Comparing micro-element profiles of various legumes conventionally grown in Serbia using an ICP-OES approach

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Keywords: micro-elements, legume species, microwave digestion, ICP-OES, chemometrics,

Legume samples belonging to the following major botanical species: common beans (Phaseolus spp; n=17), faba beans (Vicia spp; n=8), field peas (Pisum spp; n=7) and grass peas (Lathirys spp; n=6), were analyzed in this study. Samples were cultivated conventionally at the Institute of Field and Vegetable Crops in Serbia, in 2019. They were milled into flour and digested in a microwave oven, following a slightly modified and shortened method compared to the standard method for cereal grains, as provided by the manufacturer. About 0.5 g (± 2%) of each flour sample was put in a teflon vessel, where 5 ml of 65%nitric acid and 2 ml of 30%hydrogen peroxide were added. The microwave power used was 800 W, with a total digestion time of 40 minutes, with additional 20 minutes for cooling down the sample vessels to room temperature. The clear liquid, obtained after sample digestion, was diluted with 2% nitric acid and put in a glassy vial till analysis on an ICP-OES, for micro-elements iron, copper, zinc and manganese. All samples were analyzed in triplicate. Summary statistics, MANOVA and PCA were performed using the SPSS 26.0. The mean contents for Fe, Cu, Zn and Mn, respectively, were as follows: 35.9, 4.3, 43.0 and 10.1 in mg/kg of common bean; 26.0, 3.0, 25.2 and 7.9 in mg/kg of faba bean; 41.4, 3.2, 18.4 and 7.2 in mg/kg of field peas; and 26.5, 3.0, 79.0 and 10.1 in mg/kg of grass peas flour. MANOVA revealed significant differences between faba beans, field peas and grass pea in Fe content, and between faba bean and field peas in Zn content. The Fe content was the highest in the field peas and Zn in grass pea. PCA analysis showed distribution patterns of micro-elements among investigated legumes. According to the WHO, iron deficiency is the most common nutritional problem in the world, and together with zinc supplementation is recommended for severe malnutrition and related disorders. Therefore, monitoring these micro-elements in selected legume cultivars is crucial since they could represent one of the important sources in the everyday diet.

Food performances, properties, digestibility & functionalities

Poster

Fermentation of ginseng sprout extract by lactic acid bacteria reduces the inflammatory responses of lipopolysaccharide-stimulated RAW 264.7 macrophages

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Keywords: Processing, ginseng sprout, fermentation, inflammatory effect,

Chronic inflammation can increase the risk of developing pathological conditions, including cancer and cardiovascular diseases. Food fermentation is a traditional process to change the complex compounds into bioactive, functional, and nutritious compounds using microbial enzymes and microorganisms. It has several benefits for the development of functional foods. As ginseng exhibits various biological and pharmacological activities, ginseng sprouts have been developed as medicinal foods owing to their short growth period in soilless cultivation systems. To understand the functions of the fermented ginseng sprouts related to the immune response, ginseng sprout powder was used to extract with distilled water. The sterilized ginseng sprout extract was fermented by inoculating two strains of Lactobacillus and Enterococcus for 24 h. Then, the inhibitory effects of ginseng sprout extract fermentation on lipopolysaccharide (LPS)-induced inflammation in RAW 264.7 macrophages were investigated by evaluating the expression of pro-inflammatory mediators. The total polyphenol content and antioxidant activity were also estimated. Results showed that the anti-inflammatory effects of ginseng sprout extract ferment are mediated through the modulation of macrophage-mediated inflammation-associated functions, such as the upregulation of cytokines, nitric oxide, and prostaglandin E2. In addition, ginseng sprout extract ferment exerts antioxidant effects as evidenced by the increase in polyphenol content, DPPH scavenging activity, and SOD activity.

Poster

Understanding and evidencing of the Hard to Cook phenomena and its impact in red beans (P. Vulgaris) for industrial processing optimization

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In recent years, the Hard to Cook (HtC) development in beans has seen the surge of a reticence for the consumption of legumes : a high nutritional and environmental value matrix. Every single one of these hypotheses found in literature converges into a correlation between the quantifiable consequences of HtC and the thickening of the middle lamella and/or the cellular wall. This rigidification is majorly due to detrimental storage conditions (high humidity, temperature). For a better understanding of this phenomenon, it is essential to precisely study the behavior of beans during traditional preparation (soaking, cooking). Highlighting of water transfers in beans during cooking, link with structural modification of the matrix, gelatinization of the starch, modification of the pectinic walls and evolution of the texture should allow a better control of cooking.
The resolution strategies focus on (i) the understanding of the physical, chemical and biochemical mechanisms, through an adapted experimental metrology and analyses dedicated to the product and (ii) the application of an experimental methodology to determine the optimal operating parameters. Structural modifications and thermal behavior were characterized by a correlation of DSC profiles and MEBE observation.
The aging of beans modifies the internal structures and thus the kinetics of water uptake during soaking, as well as the direction of the cooking gradients inside the cotyledons. Soaking temperatures change the state of the pectin walls and the water accessibility of the bagged starch in the plant cells. The destructuration of the matrix occurs in two steps during cooking, with a two-step gelatinization of the starch. A heat treatment in excess of water is necessary to depolymerize the cell wall compounds and make the starch accessible. The time and temperature of soaking, as well as the condition of the bean before processing, have a strong impact on its cooking time and final characteristics.
The microstructure of the beans was shown to have an impact on their density and water holding capacity. A database gathering the data collected in this project has made it possible to develop densimetric and NIR sorting methods to predict the cooking behavior of different batches.

Food performances, properties, digestibility & functionalities

Poster

Effect of high-intensity ultrasound processing on carbohydrates of freshly squeezed orange juice

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Objective

Orange juice although it is the top selling and consumed, 100% fruit juice worldwide, due to its superior sensorial and nutritional characteristics, it consists of significant content of sugars making its consumption forbidden for specific groups of people. The World Health Organization recommendation for at least 10% reduction on free sugars leads the juice industries to the need of the production of low-caloric juices by reducing the free sugars present in the natural fruit juice. The ability of non-thermal technologies, such as ultrasound, to cause significant changes in the structure and functionality of carbohydrates may lead to sugar breakdown conversion. The target of the research was to study the effect of high-intensity ultrasound to the structure of carbohydrates in orange juice.

Method

Freshly squeezed orange (Valencia cv.) juice was processed under different conditions of high-intensity ultrasound (frequency 10-30 kHz, temperature 20-60ºC, 0-20 min) and conventional heat treatment (40-110ºC). The effect of each technology and process parameters on the potentiality to break down juice sugars was assessed through high performance liquid chromatography and SDS-PAGE electrophoresis. Physicochemical (color, pH), nutritional (vitamin-C, antioxidant activity, total phenolic content) and sensory characteristics of the processed juices, as well as enzymes activity (pectinmethylesterase), were also evaluated.

Results

The combination of ultrasound treatment up to 20 kHz combined with temperatures up to 40ºC and processing times till 5 min did not affect the quality characteristics of the juices. Ultrasound processing conditions of increased intensity led to carbohydrates degradation as derived from the HPLC-profiles, as well as to a decrease of the average molecular weight of polysaccharides in the orange juice.

Conclusions

The results indicate that ultrasound processing could be used as a potential processing technique for sugars molecular weight degradation in fresh juices.

Poster

Production of novel health-promoting yoghurt-type products enhanced with microalgae nutrients

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Objective
Dairy industries follow consumer demands for high quality health-promoting products of high protein and/or low-fat content. The current study focused on the research and development of innovative yogurt desserts enhanced with proteins and iron from microalgae. The partial replacement of saturated fatty acids with microalgae polyunsaturated fatty acids, was also investigated.

Methods
A specific growth protocol of Arthrospira (spirulina) platensis was developed and appropriately optimized to produce biomass enriched in iron (Fe). High pressure processing was used to extract the protein content of spirulina. Milk lipids were partially removed to be substituted by spirulina lipids, which contain ω-fatty acids. Based on analyses of quality, nutritional and sensorial characteristics, yoghurt sets of 200 g each were produced containing dried mixture of spirulina and spirulina-water-soluble-extract in a ratio of 3:1 w/w. A randomized cross-clinical study was performed for a spirulina response dose of 2, 4, 6 and 8 g dissolved in 50 g of glucose versus 50 g of pure glucose.

Results
The addition in the spirulina growth medium of 183 mg/L Fe in the form $FeCl_3$ led to the production of biomass with iron content of around 115 mg Fe/g dry biomass. High pressure at 300 MPa, 10 min, 20°C were the parameters selected for spirulina treatment, leading to higher extraction yields and purity extracts within ~2 h after processing. Based on the results of the randomized cross-clinical study, 8 g of spirulina led to a significant decrease in blood glucose concentrations (-9 mg/dL) and in arterial systolic blood pressure (-4%) 120 min post-test meal, respectively. The daily suggested consumption was set to 8 g for spirulina (including extract and dry form) and 100 mg Fe, split into 2 yoghurts per day. The produced yogurt desserts were of superior quality. The proteins and Fe content per yoghurt were estimated as 22.4 g and 50 mg, respectively.

Conclusions
The novel yoghurt-type product is expected to be a health-promoting food of daily consumption, attractive to the consumers both for its organoleptic characteristics as well as for its healthy profile.

Poster

Bioaccessibility of inorganic elements of plant-based beverages

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Keywords: Contaminants, metals, food safety, bioaccessibility,

The growing consumption of plant-based beverages has led to the need to evaluate the composition of inorganic elements in this food category. Thus, this study evaluated the presence of 11 inorganic elements (Al, Cr, Co, Ni, As, Mo, Cd, Ba, Sb, Pb, and Hg) with toxic potential in six plant-based beverages containing cocoa (S01- rice, S02- almond, S03- oats, S04- cashew nuts, S05- soy) or Brazil nuts (S06- based on cashew nuts) in their formulation, using the ICP-MS technique, as well as their bioaccessibility (%B). The sample preparation for the total concentration was performed using an ultrasound bath and the estimation of the bioaccessibility was performed according to INFOGEST 2.0 standardized method, with modifications. The total concentrations of Sb and Hg were below the limit of quantification (LOQ) (4 µg kg-1) for all samples. For As, Cd, and Pb, the total concentrations were lower than the LOQ for most samples, except for S01 (rice and cocoa-based). Total Cr was quantified in samples with cocoa, and the concentration of Al, Co, Ni, Mo and Ba was determined for all samples. The Ba content in sample S06 (16112.8±46.1 µg kg-1) stood out and was significantly higher than the other samples (more than 100 times). In the %B evaluation of potentially toxic elements, Co, Ni, and Ba were detected in all samples, with a higher %B observed for sample S04 (cashew and Brazil nuts) and a lower %B for S01 (rice and cocoa). Co and Ni showed %B between 51 and 107% for all samples. Great differences were observed for %B of Ba, both for the total concentration and bioaccessibility. This behavior shows the importance of bioaccessibility studies, since low bioaccessibility does not necessarily represent a low element intake. The %B was also higher than the LOQ of the method for the elements Al (S04, S05), Cr (S02, S03), Mo (S03, S06). The results of this study are unprecedented and can be a relevant tool in providing data on inorganic contaminants and bioaccessibility of toxic elements in plant-based beverages.

Food performances, properties, digestibility & functionalities

Poster

Evaluation of oat syrup, from oat beverage by-products for sugar reduction in food products

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Keywords: oat by-product, thermal hydrolysis, sugar reduction, food waste,

The agro-food industry is responsible for the annual production of millions of tons of food waste. At the same time, consumers are more informed and conscious about their food choices, seeking convenient, healthy, and sustainable products. In response, the industry proposes to provide natural products with limited additives, while still meeting sensory, nutritional, and safety requirements. Oats (Avena sativa L.) are the sixth largest cereal crop worldwide, becoming increasingly popular with health-conscious consumers because of their exceptional nutritional profile. They are particularly rich in dietary fibre, phytochemicals and essential nutrients such as vitamins and minerals. In this context, oats are chosen by consumers who prioritize health-promoting properties, as well as sensory appeal. This study aimed to transform an oat drink by-product into a new added-value product, that can be used as a sugar-replacement ingredient in food products. To release the by-product sugars, different hydrolysis processes were carried out. Thermal hydrolysis using water was carried out with proportions of 4:10 and 1:1 (residue: solvent). From this by-product hydrolysis, the supernatant residue was separated by centrifugation (10,000rpm, 10min) and the concentrations of sugars (mono and disaccharides) were analysed from the liquid fraction using the HPLC. The Brix for the obtained supernatant was also determined, as well as the sweetness index as a function of sucrose. Aqueous thermal hydrolysis (1:1 ratio, temperature of 121 ºC for 15 minutes, and pressure of 1 atm) was found to be the most effective process, resulting in fibres with good sweetening power. According to sugars HPLC profiles, the resulting supernatant liquid exhibited a sucrose concentration of 72.35 ± 8.13 g, glucose concentration of 56.59 ± 6.23 g, and fructose concentration of 2.89 ± 0.05 g per 100 g of sample, with a sweetness index of 1.24. The liquid fraction was then concentrated to produce an oat syrup with a Brix value of approximately 67º, indicating high levels of dissolved solids. In conclusion, this oat syrup exhibits promising sweetening properties and could potentially serve as a substitute for sucrose in certain food products, contributing to reducing food waste and promoting further a circular economy.

Food performances, properties, digestibility & functionalities

Poster

Interest of choline chloride for salt reduction in bread

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Cereal products, and in particular bread, are the main source of salt in human diet. However, salt is a critical ingredient in bread making, and its reduction can have a negative impact on bread quality. Choline Chloride (CC) is a quaternary ammonium salt that has a cation of choline with a chloride anion. It is able to act as a substitute for salt. Nutritionally, CC is an essential nutrient of vital biological importance. This study aims on the one hand to develop a bread recipe reduced in salts (by -50%) and partly substituted by CC. On the other, it aims to study the acceptability for consumers of this double innovation, combining the addition and withdrawal of a nutrient.
The effect of CC on bread properties was studied during baking, cooling and storage of bread. CC is involved in each of these manufacturing steps, and improves the properties of a salt reduced bread. The staling study highlighted the positive effect of CC on bread texture and on the retrogradation of starch. The CC added to the recipe seemed to not only slowdown the firming over time, but also to reduce the hardness of 3N and 2N compared to 0% NaCl and 100% NaCl bread. Indeed, the CC restricts the recrystallisation of amylopectin due to less availability of water in the matrice, and decreases the staling kinetics of the bread.
Sensory test showed that CC tends to increase the saltiness in salt-reduced bread.
The acceptance of reduced-salt and CC-enriched bread was investigated in three focus groups, mixing blind tests, information input and spontaneous evocations. Three groups of eaters likely to accept the tested product have been identified:health-oriented young people, young parents who want to educate children to engage in a healthy lifestyle, and people broadly sensitive to nutritional information. Consumers with a “pleasure and taste” oriented profile were more sceptical of the new bread formula because of greater attachment to traditional bread.
In conclusion, CC is a relevant alternative to salt that combines technological and sensory benefits;its success will depend on the consideration of issues related to social acceptability.

Food performances, properties, digestibility & functionalities

Poster

Mucilage from Yam (Dioscorea Rotundata): Physico-Chemical, Rheological and Functional Characterization and Applications in Food Industry

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This research aims to characterize the freeze-dried mucilage of yam (*Dioscorea rotundata*) and evaluate its potential use as a stabilizer in mango nectar and vanilla-flavored ice cream. Yam mucilage was characterized physicochemically, rheologically, and functionally, for its later use as a stabilizer in mango nectar evaluating the concentration of stabilizers (0.01 and 0.03%) and mucilage: carboxymethyl cellulose (CMC) ratio (20:80, 50:50, 80:20 and 100:0). Likewise, the stabilizing properties of the mucilage were evaluated in soft vanilla cream ice cream, with the same factors changing the concentration of stabilizers (0.4 and 0.8%). The effect of the independent variables on the dependent variables with the analysis of variance (ANOVA) was determined and the Tukey multiple rank test was used to select the treatments that presented the best stability using the RStudio software. The proximal analysis of the mucilage showed that it contains 27.18% of protein and 18.94% of ash, which positions it as a possible source of minerals, and potential as an emulsifier. Infrared spectroscopy showed the most pronounced wavelength at 1638 cm-1 present at the peptide bond R-CO-N corresponding to the amide group and the thermogravimetric analysis yielded a multi-stage decomposition starting to decompose the material after 220ºC, Which allows the mucilage to be used up to this temperature. The functional properties of the mucilage reflected high solubility with values between 88 and 96.96% and swelling power of 75,69%, which show the water absorption of the mucilage. In addition, the suspensions of the yam mucilage presented a rheological behavior of the non-Newtonian fluid, specifically dilating. On the other hand, yam mucilage did not present good results as a stabilizer in mango nectar, because the best treatments were when using 20:80 mucilage:CMC ratio in both concentrations (0.01 and 0.03%), while the ice cream showed good behavior, which is evidenced by the results of physical stability when 100% mucilage was used, because the mucilage acts well as an emulsifier. However, the coefficient of consistency of the ice cream mixture was higher when the ratio of 20:80 mucilage: CMC with 0.8% stabilizers.

Food performances, properties, digestibility & functionalities

Poster

Effect of post-harvest treatment on quality attributes of moroccan pomegranate variety “sefri ouled abdellah” during cold storage

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Introduction: Pomegranate (Punica granatum L.) has received special attention from fruit growers and consumers around the world due to its diverse functionality and famous nutritional benefit in the human diet. Harvested pomegranate fruit is highly susceptible to high weight loss and deterioration in technological quality and nutritional components during postharvest handling and storage. Cold storage is one of the best common methods of conservation technologies performed to extend its availability in the market. This leads to myriad problems of this method that low temperature causes deterioration of quality and nutritional values in pomegranate fruit. The ultimate aim is to find a new way to effectively maintain fruit quality during cold storage.
Tools and method: Thus, the effects of treatment based on Imazalil on their technological quality (Weight loss, color attributes (L*, a*, b*, C and h°), pH, titratable acidity, and total soluble solids), and nutritional components (total anthocyanins contents (TAC), and total phenolics contents (TPC)) in Pomegranate fruits of the variety ‘Sefri Ouled Abdellah’ collected from the Béni Mellal region and immediately stored at 4°C for 120 days.
Results: Fresh untreated Pomegranates showed high general-quality deterioration (weight loss, color changes, acidity, and total soluble solids) during cold storage. The Treatment based on Imazalil was more effective in delaying the changes and losses in bioactive components when compared with those in control.
Conclusion: This experiment adds to a growing corpus of research showing treatment based on Imazalil is effective in prolonging the technological quality and nutritional components of pomegranate in postharvest during cold storage. Our data suggest that we still have a long way to find the best treatments and storage conditions for pomegranate fruit.
Keywords: Pomegranate, Cold storage, technological quality, nutritional components, Morocco.

Poster

Novel approaches to oil structuring through capillary suspensions

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Oil structuring has attracted increasing attention because of its potential use in various applications in the food, pharmaceutical and biotechnology industries. This work aimed at structuring sunflower oil through the formation of capillary suspensions using wheat middlings (WM) and pure cellulose (CL) as a structuring solid fraction. High-pressure homogenization (HPH), which is an emerging, purely mechanical cell disruption technology, was used as a wet milling technique directly applied on oil-dispersions of WM or CL, at 80 MPa and 25 °C for 20 passes. The HPH treatment enabled the reduction of particle size by one order of magnitude, causing also fiber activation and, in the case of WM, the release of high value-added intracellular compounds with high antioxidant activity into the sunflower oil. The addition under high-shear mixing of a secondary immiscible fluid (i.e. water) as a function of saturation ratio (volume of water per total volume) in a continuous phase (i.e. oil) of HPH-treated particle suspension drastically altered the rheological behavior, evaluated by using a rotational rheometer equipped with a concentric cylinder, and the strength of these suspensions due to the formation of a sample-spanning particulate 3D network. This phenomenon can be attributed to the capillary bridge forces of the two fluids acting on the fibrous solid particles, which cause the transition from liquid to gel-like state. The WM-in-oil-dispersion at 30 wt% of particle fraction treated by HPH with the addition of 50 wt% of saturation ratio exhibited a high apparent viscosity and apparent yield stress (about 300 Pa). While, the higher viscosity for CL-in-oil dispersion is achieved at 15% of saturation ratio. Remarkably, WM as opposed to CL released the antioxidant compounds in the oil which contributed to slowing down the oil oxidation phenomena during the entire period of storage. In conclusion, the obtained oleogels are very promising materials for the formulation of healthier and more sustainable food products in replacement of solid fats, enabling to reduce the overall caloric content while especially adding the benefits related to the dietary fiber content of WM, as well as exploit the recovery of valuable bioactive compounds still present in the AFRs

Food performances, properties, digestibility & functionalities

Poster

Comparison of techno-functional properties of ora-pro-nóbis (Pereskia aculeata Miller) flour and its protein concentrate

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With the world's population growing and the concern of consumers for healthier and sustainable products, there is an urgent need for alternative plant protein. The ora-pro-nóbis is a Brazilian leafy vegetable with great potential for exploration, owing to its high protein content (17 to 28%) and digestibility (approximately 85%). This study aimed to investigate and compare the techno-functional properties of ora-pro-nóbis flour (OPNF) and its protein concentrate (OPNPC). The OPNPC was obtained by alkaline solubilization at pH 10.0 and isoelectric precipitation at pH 3.5. The water solubility, water and oil holding capacity, foaming capacity and stability, emulsifying activity and stability indexes, and in vitro digestibility were the properties evaluated. The protein content in OPNF was 24%, while the OPNPC exhibited almost 53% (g.100g-1) on a dry basis. Water holding capacity and emulsifying stability index were the only techno-functional properties that were found to be higher in OPNF (5.44 g.g-1 and 105.16 min, respectively) than in OPNF (2.28 g.g-1 and 86.98 min, respectively). OPNPC showed better in all other techno-functional properties evaluated: oil holding capacity (5.44 g.g-1), emulsifying activity index (24.81 m2.g-1), foaming capacity (61.52%) and foaming stability (88.46%). The protein concentration process increased the water solubility of the material more than 3.5 times (OPNF: 23.37%; OPNPC: 87.38%). The improved solubility of the concentrate can be attributed to the remotion of hydrophobic constituents of the flour, such as fibers and others carbohydrates. Moreover, the increased solubility of OPNCP can account for the significant increase in foaming capacity. Regarding in vitro digestibility, there was no significant difference ($P > 0.05$) between samples. Overall, the superior techno-functional properties of the OPNCP highlight that its use as an ingredient is a good alternative for developing new plant-based products.

Poster

High hydrostatic pressure as a tool to modulate techno-functional properties of quinoa (Chenopodium quinoa) protein and nutritional effects

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Quinoa protein has attracted growing attention of scientists due to its nutritional quality and it is referred to as a sustainable and promising plant-based protein source. Modulating plant-based proteins' properties has recently received interest in order to make them multifunctional ingredients for food systems. Quinoa protein concentrate (QPC) dispersions (5 %; w/v) were subjected to high hydrostatic pressure-HHP (200, 300, 400, 500 and 600 MPa; 25 °C; 20 min). Non-pressurized sample was used as a control. The effects of HHP on techno-functional properties and in vitro digestibility (IVDP) of QPC were evaluated. Water absorption capacity of QPC (3.3 g/g) was significantly ($P<0,05$) improved after HHP, with a maximum at 400 and 500 MPa (4.4 and 4.3 g/g). Fat absorption capacity (2.5 g/g) was however unaffected by the process. Emulsifying activity and stability indexes of CPQ were both decreased with HHP application. Although foaming capacity of QPC was slightly reduced above 200 MPa, foam stabilities at 10 and 60 min were practically unchanged by HHP. It is noteworthy that modulation of QPC techno-functionalities by HHP treatment was achieved with no noticeable loss of its nutritional value (IVDP). The major changes in QPC properties, according to these findings, indicate that HHP was more effective at exposing hydrophilic groups of its amino acids. This could be useful in the development of alternative plant-protein ingredients for gluten-free baked products with better mouthfeel, for example. Moreover, HHP is environmentally friendly and its uses meet the essential requirements for sustainable and clean-label ingredients production.

Poster

SFE-CO2 PROCESS TO OBTANING HIGH BIOACTIVE EXTRACTS FROM OPUNTIA FRUITS. A COMPLETE STUDY OF THEIR BIOACTIVE PROFILE AND NUTRACEUTICAL POTENTIAL

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In the present work, supercritical fluid extraction (SFE) with CO2 as solvent and EtOH/water (v/v) as co-solvent was optimised by applying 23 factorial experimental design for the extraction of betalains (betacyanins and betaxanthins) and phenolic compounds from Opuntia ficus-indica fruits var. Colorada and Blanca Buenavista, and Opuntia stricta var. Dillenii fruits. SFE-CO2 conditions were a pressure of 250 bar, CO2 flow of 40 g CO2/min and temperature of 50°C, being a dynamic time of extraction of 60 min. The HPLC-DAD and HPLC-MS betalains and phenolic compounds profiles of the SFE-CO2 obtained extracts were studied. Cell viability and anti-inflammatory activity were tested using the murine macrophage cell line (RAW 264.7), measuring the cell viability by the CellTiter96®AQueous One Solution Cell Proliferation Assay. For anti-inflammatory activity, the Nitrite (NO2−) is one of two primary and stable breakdown products of nitric oxide, in which results were expressed as the percentage of inhibition of nitric oxide production (% NOX). And to evaluate cellular antioxidant activity (CAA) Human colorectal adenocarcinoma cells (Caco-2) were used.

Food performances, properties, digestibility & functionalities

Poster

Flat bread originality, functionality and developments (a review)

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Flat Bread in the Middle East is described as (Aeish) which means living the continuation of life for human, which he consumes in a proportion that covers more than 50% of the total daily energy daily intake by the human. Flat Arabic bread in Jordan and what surrounds it is the most productive and interesting food product by homes, producers and by governments, as its availability to the consumer is considered food security. Historical monuments in Jordan and surrounding countries in the Middle East have proven that its inhabitants since time immemorial have produced flatbread. For the diversity of social habits, there are a large number of names that characterize flatbread, some of which are classified according to its ingredients or according to the way it is baked or the place or geographical area in which it was produced and according to the shape and end use as well.The production of flatbread requires flour with specific rheological properties of elastic, resistance to stretching, viscosity, starch properties and others to contribute to the ease of handling of the dough during the stages of the production process to reach the production of distinctive flatbread to achieve the satisfaction of consumer desires. Basic Flatbread is low in fat if not added and is a source of dietary fiber when produced from whole grains of cereals. In addition to a nutrient that provides the body with energy, Flatbread considers a functional food to provide the body with some of the phytochemicals that are beneficial to health. Countries have been interested in the areas of development in the production of flatbread and the production process has moved over time from manual to automatic and even digital in modern inventory, as well as the diversity of the introduction of other ingredients and food additives to extend the shelf life and the introduction of packaging for bread , as well as the expansion of the production specialty flatbread for consumers with specific health requirements such as high protein low protein ,high fiber, free gluten and others .

Poster

Antimicrobial activity of microencapsulated anthocyanins from blueberry (Vaccinium corymbosum)

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Throughout history, the different essential nutrients and the healing and preventive properties for diseases that food provides with have been discovered. However, in order to take advantage of these benefits, many times the food must be consumed as it is provided by nature, due to the fact that many of these compounds are easily degraded by the temperature, light or pH conditions of the environment. For instance, anthocyanins are compounds that have not only shown anticancer activity but also have antimicrobial properties. These could help extend the products shelf life in a more organic way compared to the preservatives currently used in the industry, but in order to preserve these properties it is necessary to carry out a microencapsulation. Microencapsulation techniques allow preserving the properties of the intact anthocyanins in a better way. Through antimicrobial activity tests such as antibiograms, that compare all the compounds at the same concentrations, it can be found how the microencapsulation helps preserve the antiproliferative properties of microorganisms, making it a viable option for the conservation of foods.

Food performances, properties, digestibility & functionalities

Poster

VITAMIN C: QUANTIFICATION AND BROWNING REACTIONS IN YOGURTS

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OBJECTIVE

The objective of this work is to develop a method to quantify vitamin C in yogurts added with this vitamin. Moreover, it is also to identify possible relations between its presence and the Maillard reaction, quantifying the hydroxymethylfurfural (HMF) marker.

METHODS

The methods for the determination of vitamin C and HMF content in yogurt were developed using a High Performance Liquid Chromatography (HPLC), Waters brand equipment, model 1525 UV-Vis detector (PDA - Photodiode Array Detector). To determine vitamin C, the method was developed from adaptations of the AOAC Official Method 2012.22, analysis time was 8 minutes and the injection volume was 20 µL. The quantification of HMF was performed in isocratic mode, mobile phase composed of water and acetonitrile (95.5:4.5), flow rate of 1 mL.min-1. Water spherisorb column (150 mm ×4.6 mm; 3µm; ODS2), kept at 30°C, was used. The injection volume was 20µL and the wavelength of 284 nm. Parameters of selectivity, linearity, precision (repeatability and intermediate precision), accuracy, limit of detection (LOD) and quantification (LOQ) and recovery were evaluated.

RESULTS

The analytical curves were constructed over a concentration range of 0.32 to 5.00 µg/mL for HMF and 0.25 to 10.00 µg/mL for vitamin C, the R2 values were >0.999. The methods meet the acceptance criteria for a 95% confidence interval, with DPR less than or equal to 5 for precision and a range of 90 to 110% for accuracy. The following LOD and LOQ were obtained: Vitamin C (0.011 µg/mL and 0.034 µg/mL) and HMF (0.037 µg/mL and 0.11 µg/mL).

CONCLUSIONS

The statistical treatment demonstrated that the method can be considered accurate, selective, linear over a wide working range, precise and sensitive, presenting detection and quantification limits compatible with the analytical curves and samples analyzed.

Food performances, properties, digestibility & functionalities

Poster

Egg yolk lipoproteins as natural stabilizers and emulsifiers to prepare Pickering emulsions as solid fat replacer

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Egg has been a major food in the world due to its well-rounded nutritional values and functional properties. Lipoproteins from egg yolk are of particular importance as natural stabilizers and emulsifiers among food ingredients, which have been engineered to develop functional foods with innovative applications. Our groups have exploited egg yolk low (LDL) and high (HDL) density lipoproteins to prepare high internal phase Pickering emulsions (HIPEs) and comprehensively studied their roles as a stabilizer. Both LDL and HDL exist as homogenous nanoparticles with an average size of 50-70 nm and amphiphilic nature, having a contact angle close to 90°. HIPEs were studied by varying compositions of 75%–90% oil phase and 25%–10% aqueous phase containing 0.5%–2% LDL or HDL, under various pH conditions. Rheological measurement, confocal laser scanning and optical microscopes imaging together with digital photos revealed the solid gel network, the strength of which was dependent upon oil volume fraction and LDL concentration. Likewise, as expected, the emulsifying ability showed a strong correlation with the pH conditions, too. HIPPE that was prepared at pH 5 exhibited small droplet size, high viscosity and gel stability. The optimal formulation of HIPEs was found as 80% oil and 2% LDL or DL concentration, which exhibited small droplets under 10 µm with negligible aggregations, even after four weeks of storage under refrigeration or heating at 90 ? for 30 min. After three freeze-thawing cycles, the HIPEs were demulsified losing their gel structure, but a simple re-homogenization was able to reconstitute the gel network identical to the original microstructure. Encapsulation of curcumin into Pickering HIPEs provided exceptional photostability (around 80% retention rate) against ultraviolet radiation and improved its bioaccessibility from 10% to 50% during in vitro digestion. Our findings have demonstrated the promising potential of egg lipoproteins-stabilized HIPEs as a delivery system for lipophilic compounds and meanwhile as a substitute to saturated/trans fats for modulating the texture of semi-solid foods with added health benefits.

Food performances, properties, digestibility & functionalities

Poster

Impact of leavening times on structure and in vitro digestibility of a bread with lentil flour

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Bread represents a staple part of the Mediterranean diet with a complex crumb structure and usually a high glycaemic index. Leavening is a step in the breadmaking process that can be crucial in determining the final characteristics of a bakery product such as bread. The effects of different leavening times (60 and 105 minutes) and the presence of green lentil flour on structure and physico-chemical and nutritional properties of breads were investigated.
Farinograph characteristics of the flour blend dough were studied by using a Brabender farinograph. The 20% of lentil flour strongly influenced all farinographic properties of dough except of dough development time. In particular lentil flour decreased the stability due to weakening of the gluten network. Leavening time affected bread physico-chemical properties and macrostructure, leading to a significant reduction in moisture content, an increase in weight loss and pH of bread crumb as leavening time increased. Image analysis results to be an effective technique for measuring bubbles structure of breads. Crumb macrostructural properties such as Young's modulus were well correlated to the Image Analysis results such as gas bubble area fractions. Bread quality attributes and in vitro digestibility were significantly influenced by the structure resulting from different leavening times and formulation. The in vitro starch digestibility was analysed enzymatically, determining the amount of released glucose during starch digestion. Bread samples showed a similar total starch content ($P > 0.05$), while the more compact crumb structure of samples led to lower Rapidly Digestible Starch and estimated Glycemic Index. The protein bands of bread samples leavened for different times showed different intensities. In particular, samples leavened for the shortest time (60 minutes) exhibited the weakest protein bands, which may depend on the strength of starch–gluten interactions. The α amino nitrogen release at the end of digestion reached the lowest values in bread leavened for the longest time (105 minutes).
The results of this research provide interesting information on how and to what extent leavening time can affect the structure and other properties of bread enriched with different content (0 and 20 %) of lentil flour.

Food performances, properties, digestibility & functionalities

Poster

Using a novel soft robotic swallowing setup to adapt food products for specific swallowing disorders

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Age-related physiological changes can induce swallowing disorders and strongly impact the quality of life. Texture adaptations should ensure safe swallowing but also maintain pleasure during consumption.
Objective: A novel in vitro soft robotic swallowing setup was developed and used to identify promising rheological adaptations of food to meet the specific needs of people with swallowing disorders.
Methods: A range of thick liquid food were adapted to different levels from the International Dysphagia Diet Standardization Initiative (IDDSI) using natural thickeners. Their performance was evaluated using an in vitro swallowing model that simulates the interaction between the tongue and the palate when the bolus is transported during the oral phase of swallowing. Different conditions were mimicked; (i) healthy swallowing and (ii) specific swallowing disorders such as xerostomia, sarcopenia, and uncoordinated swallowing. Food boluses were then evaluated to characterize their shear and extensional viscosities. Moreover, timings of bolus out, and residues remaining after swallowing were assessed in triplicate.
Results: Levels 3 and 4 from IDDSI were achieved by using natural thickeners. Similar levels of shear viscosity could be reached with natural and commercial thickeners. The quantity of residues after swallowing in the in vitro setup increased within the following conditions; uncoordinated swallow > sarcopenia > xerostomia > healthy conditions. Food products with lower levels of shear viscosity exhibited fewer residues but shorter timings of bolus out, which might alter swallowing safety. Conclusions: The study shows an interest in imitating swallowing disorders in vitro to improve the assessment of food products for patients with swallowing difficulties.

Poster

Effect of oleogel:hydrogel ratio on rheological properties of bigel produced with potato starch and glycerol monostearate

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Bigels are a promising structured system for the food industry. This work aimed to develop and study rheological properties of bigels obtained from six different oleogel:hydrogel (O:H) ratios, using potato starch (PS) as structuring agent for the H-phase and glycerol monostearate as structuring agent of the O-phase. First, a gelation evaluation of PS was evaluated to define the aqueous phase concentration to be used. All rheological measurements were carried out using a stress-controlled rheometer equipped with a Peltier system. Strain sweeps were performed to determine the linear viscoelastic region of bigel. The frequency-dependent behavior of bigel was accessed by recording storage (G') and loss (G'') modulus as a function of frequency. The behavior of the elastic (G') and viscous (G'') modulus was investigated during cooling and heating stages, disclosing sol-gel and gel-sol transitions, respectively. Bigel was stable formed even with a small addition of O-phase, although a ratio of 20:80 formed a harder structure system. The maximum limit of linear viscoelastic region was between 0.01% and 0.1%, although system with more H-phase was more susceptible to the application of mechanical forces. Above these strain values, dynamic modulus showed pronounced decay and the sample response was dependent on the magnitude of deformation. At this stage, a crossover point occurred, indicating that gels underwent permanent deformation caused by the rupture of the structural network. All the samples, showed a dominate storage modulus (representing the elastic property) over the loss modulus (depicting the viscous property), pointing to a gel-like behavior. All bigels showed a typical abrupt phase transition at 50 ºC demonstrating an application limit of this system. After three months of production was realized a visual analysis and not observed any phase separation in the system with higher O-phase, while the ratio 20:80 shows a little water liberation. Thus, this study unveiled the potential of PS for the development of low cost bigel to form systems with tailored textures for application as trans-fat substitute in food. For future studies, the best formulation of bigels is going to be selected for curcumin vehiculation, aiming at improving antioxidant and antibacterial activity to the system.

Food performances, properties, digestibility & functionalities

Poster

Optimal temperatures to fractionate palm oil through centrifugation and critical concentration of fat from palm oil in soybean oil

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Palm oil (PO) is an important player in the food industry, it can be used as ingredient in foodstuffs, such as margarines, ice creams and spreads, and as heat transfer medium for frying. PO is a reddish vegetal oil obtained through pressing, rich in saturated fatty acids. At room temperature, it is possible to observe that PO presents two phases, a white precipitate (saturated fatty acids) and a reddish supernatant oil. At lower temperatures, PO presents a solid like behavior, which could indicate the capacity of saturated fatty acids from PO to structure oil. Vegetal oil structuration is due to fat crystallization, which can be induced by reducing the temperature. This work aimed to study the influence of storage and centrifugation temperature on the separation of oil from palm oil (OPO) and fat from palm oil (FPO), and to determine the minimal concentration needed of FPO to structure soybean oil. PO was heated at 90 ºC for 30 minutes. Samples of one gramme were transferred to previously weighted Eppendorf tubes of 1.5 mL. Eppendorf tubes were kept at controlled temperature for 24 hours and centrifuged at controlled temperature (10 000 rpm for 15 minutes). The supernatant oil was drained and the Eppendorfs were weighted to obtain the yield of fat and oil fractions from palm oil. Temperatures of 10 ºC, 15 ºC, 20 ºC and 25 ºC were chosen for the storage chamber and for the centrifugation. Response surface methodology pointed out that storage and centrifugation at 20 ºC is the best temperature to fractionate PO. The thermal behavior of PO, FPO and OPO were determined by differential scanning calorimetry during cooling from 90 ºC to -30 ºC. OPO presented no crystallization, corroborating to indicate the purity of the OPO. FPO was able to solidify soybean oil at concentration of 50 % (w/w). FPO and OPO presented significant thermal differences and are promising ingredients for industrial applications in food, cosmetics, and chemical products. Acknowledgement to FAPESP for the scholarships nº 2021/08305-1 and nº 2020/02734-5 and financial support n° 2020/05254-4.

Food performances, properties, digestibility & functionalities

Poster

Evaluation of impact of emulsion matrix on survival of Salmonella during simulated gastric digestion

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Summary:
This study used simplified water-in-oil (W-O) emulsion and oil-in-water (O-W) emulsion to demonstrate the protective effect of W-O emulsion on *Salmonella* survival against gastric digestion stress.

Introduction: *Salmonella enterica subsp. enterica* serovar Typhimurium is one of the emerging foodborne pathogens worldwide. While its resistance to acid and osmotic stresses as well as its pathogenicity have been investigated over the years, there is a necessity to systematically study how food matrices impact *Salmonella*'s survivability in the digestive tract.

Method:
In this study, simplified water-in-oil (W-O) emulsion and oil-in-water (O-W) emulsion were prepared with peanut oil and DI water with 10% dispersed phase and stabilized with 2% (w/v) soy lecithin for W-O emulsion or 3% (w/v) sunflower lecithin for O-W emulsion. During the homogenization process, samples were inoculated with *Salmonella* in oil or water phase and equilibrated at room temperature (21 ± 2 °C) overnight. The emulsion matrices were then challenged with simulated gastric fluid (SGF) (pH 2, 3g/L pepsin) facilitated with stomacher mixing at 37 °C, and samples were taken periodically, serial diluted, and plated on tryptic soy agar (TSA) to measure bacterial inactivation.

Results:
When *Salmonella* was inoculated in the dispersed phase (water) of the W-O emulsion, 2.4±0.41 log CFU/ml total reduction was achieved after 120 minute of SGF exposure. In contrast, a significantly ($P<0.05$) higher 5.08±0.44 log CFU/ml reduction was achieved when it was inoculated in the dispersed phase (oil) of the O-W emulsion. A similar trend persisted when *Salmonella* was inoculated in the continuous phases (oil in W-O emulsion and water in O-W emulsion), in that higher reduction was observed in O-W emulsion than W-O emulsion ($P<0.05$), indicating that protection offered by W-O emulsion to *Salmonella* inactivation was independent of its phase of inoculation.

Significance:
W-O emulsion offers better protection to *Salmonella* against inactivation than O-W emulsion during simulated gastric digestion indicating food matrix can affect *Salmonella* survivability during digestion.

Poster

WATER-IN-OIL HIGH INTERNAL PHASE EMULSIONS STABILIZED BY SUNFLOWER WAX AND PGPR

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High internal phase water-in-oil emulsions (W/O HIPEs) are two-phase systems that contain at least 74 % (w/w) of water droplets dispersed in an oil-based surrounding medium. Such emulsions exhibit outstanding solid-like rheological behavior, which makes them suitable to be applied as low-calorie fat replacers. HIPEs are currently stabilized by semi(synthetic) surfactants (mainly PGPR) due to the presence of a high-water content, and their replacement by food-grade emulsifiers is still a challenge. In view of this, this study aimed to identify natural ingredients to partially replace PGPR in W/O HIPEs formulation. For this, we used two different sunflower waxes that are mainly composed of fatty acids and fatty alcohols. The difference between conventional (SW) and hydrolyzed (HSW) sunflower wax is that the former shows a longer chain and is more hydrophobic than the latter. Using a conventional dripping process, W/O HIPEs containing 80% of dispersed phase were produced regardless of the wax concentration (0 - 2%, w/w) and using a fixed concentration of PGPR (0.5%, w/w). Our results showed that increasing wax concentration reduced the droplet sizes of fresh W/O HIPEs (~ 44 and ~74%, corresponding to the same SW and HSW content), resulting in better kinetic stability both at 5 ºC and 25 ºC for 60 days. The increased stability was even more pronounced for emulsions with SW, which can be associated with the higher hydrophobicity promoted by long and saturated fatty acid chains (C26-C32). Furthermore, the storage modulus (G'), obtained from oscillatory rheology, overcame the loss modulus (G") when waxes were added into the formulation. This indicates the presence of a more elastic crystalline structure, which was also corroborated by polarized light microscopy. Therefore, our study indicates that SW can improve the rheological properties and, consequently, the stability of W/O HIPEs, allowing the development of a colloidal system containing natural ingredients with high structuring properties. In addition, our study makes it possible to understand the functionality of waxes as W/O HIPEs stabilizers that can be excellent fat replacers, contributing to the texture and sensory properties of food products.

Keywords: Sunflower waxes, food emulsions, W/O HIPEs, fat replacer and stability.

Food performances, properties, digestibility & functionalities

Poster

Evaluation of the textural properties of cream ice cream with partial substitution of powdered milk for quinoa flour

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The increase in the consumption of plant-based foods, coupled with the preference for nutritious, healthy and sustainable foods is a reality, and the markets must be prepared to meet this demand. The usual composition of cream ice cream, a product with high global demand, has been partially and/or totally modified through the use of legume and/or Andean grains, seeking to meet criteria such as new food trends, the absence of compounds that can generate adverse reactions in the consumer, environmental commitment and of course benefits not only nutritional but also for health. Quinoa, an ancestral grain of Andean origin, is an exceptional food, recognized for its nutritional quality and the presence of bioactive compounds, as well as for its adaptation to various climatic conditions. Its partial use in cream ice creams makes it possible to reduce some undesirable compounds (lactose, saturated fats) and incorporate new ones that are beneficial (fiber, phenolic compounds, phytosterols) and that are not found naturally in this product. The present investigation evaluated the effect of substituting skimmed milk powder for quinoa flour of Rosada from Huancayo and Pasankalla varieties, on the proximal composition, overrun, hardness, melting speed and viscosity of an ice cream with the incorporation of Lactobacillus casei. The evaluation was carried out during 28 days of storage (-18 °C). In each one of the flour substitutions of 25, 50 and 100% were made, and a control was also made. The results indicated an increase in the content of unsaturated fats, carbohydrates and crude fiber respect to the control, this being higher in the case of the Pasankalla variety. A significant effect of quinoa flour concentration on overrun, viscosity and melting rate ($p<0.05$), but not on hardness, was observed when the treatments were compared with the control. The use of quinoa flour reduced the content of saturated fat and lactose, and added fiber to the ice cream. The overrun and the fusion speed were affected, generating an increase in hardness, although the latter was not significant.

Keywords: Quinoa, Pasankalla, Rosada de Huancayo, ice cream, hardness, viscosity, overrun

Food performances, properties, digestibility & functionalities

Poster

Molecular characteristics of chickpea protein fractions: Hydrophobicity and structural analysis using Raman spectroscopy

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Chickpea protein is a mixture of protein consisting of several fractions, including salt-soluble globulin, water-soluble albumin, and dilute acid/alkali-soluble glutelin. Chickpea protein isolates (CPI) contain a high fraction of globulins, representing 80% of the total seed proteins. Globulin can be further subdivided into 11S legumin (CL) and 7S vicilin (CV) subunits. These fractions are responsible for most functional properties of CPI, but the molecular characteristics are not fully understood. This study is aimed to compare the hydrophobicity and structural properties of isolated globulin, legumin, and vicilin fractions from chickpea. Alkaline extraction-isoelectric precipitation and modified salt dissolution-precipitation method were performed to produce CPI, CL, and CV fractions. The samples were characterized by surface hydrophobicity (fluoresce method), sulfhydryl group content (Ellman's method), and electrophoresis (SDS-PAGE). In addition, both hydrophobicity and structural properties were characterized using Raman spectroscopy. The protein content in globulin, legumin and vicilin fractions reached over 91%. The results showed that the fractions had differences in their molecular characteristics. Vicilin fraction had significantly ($p<0.05$) lower surface hydrophobicity, indicating less exposed hydrophobic residues or patches; lower free and total SH groups, and disulfide bond content than legumin and globulin. According to the results of SDS-PAGE, the vicilin fractions showed subunit bands with lower MW, ranging from 50 to 10 kDa, implying heterogenous polypeptide subunits. Interestingly, Raman spectroscopy analysis exhibited a high content of both α-helix (~46%) and total β-sheet (~38%) secondary structure in CPI. The highest percentage of β-sheet was found in the vicilin rather than in the legumin fraction. Results that could be interesting to study and understand its impact on digestibility. The lower hydrophobicity and disulfide bond in vicilin was detected in Raman spectra, and an increase in the intensity ratio I_{1360}/I_{1340} was identified indicating a buriedness of the tryptophan residues. The results confirm that the molecular properties of vicilin fraction play an important role in influencing the structural characteristics of CPI. The characterization of hydrophobicity and structural properties of chickpea protein fractions provided a certain theoretical basis for understanding their interaction behavior and functional characteristics and the potential application of these legume proteins for the development of products

Poster

Impact of incorporations of anionic polysaccharides on rheological and structural characteristics of quinoa protein isolate suspensions

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Proteins and polysaccharides promote non-covalent interactions such as electrostatics and hydrophobic interactions. Concentration, ratio, pH, and ionic strength are crucial parameters for stabilizing the whole system. The complex properties are mainly determined by the charge density of the polyions. The viscoelastic properties of electrostatic complexes are also influenced by the secondary structure of proteins with preferential interaction with unordered parts of the polysaccharide chains. The objective of this study was to understand the role of electrostatic interactions between polymers in inducing an increase in viscosity. Rheology and structural characteristics of quinoa protein isolate (QPI) suspensions and complexes with two anionic polysaccharides [xanthan gum (XG) and pectin (PEC)] were analyzed as a function of pH and ionic strength. Physicochemical properties in terms of zeta-potential, hydrophobicity, solubility, and rheology behavior were determined and the secondary structure of QPI was examined by Raman spectroscopy. The results showed that the type of anionic polysaccharide significantly impacted the increase of viscosity of QPI suspensions. The XG exhibited the most strengthening effect of the complex network increasing the viscosity and elastic component (G´) of QPI suspensions. A maximum viscosity was found at pH 3.0 when compared with pH 7.0 or pH 8.0; pH at which the attractive electrostatic interactions are stronger. The ionic strength did not generate a significant impact on the increase in the viscosity of the protein systems. Increasing ionic strength diminished the interaction of protein and anionic polysaccharides. Also, the change of quinoa protein conformation was related to the type of hydrocolloids added, the acidic pH, and the ionic strength. The were no significant differences in protein secondary structure between quinoa complex with XG and control samples. Raman's studies suggested that QPI-XG and QPI-PEC electrostatic associations induced different conformational changes in the polysaccharide backbone and QPI tertiary structure as a function of pH and ionic strength. The research would enrich the QPI applications in plant-based texture-modified beverages. Understanding rheological behavior is especially important during food processing to control the stability of food/beverage products.

Poster

Effect of agitation and temperature on the enzymatic synthesis of oligosaccharides and dextran in orange juice

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The production of potentially prebiotic fruit juices has been extensively investigated, mainly by enzymatic via. However, there is a lack of studies involving scale-up and the importance of some process parameters. This work evaluated the effect of temperature and agitation on the synthesis of oligosaccharide and dextran in orange juice by dextransucrase from Leuconostoc mesenteroides B-512F. Firstly, the syntheses were performed in a batch reactor at 30 °C, with a synthetic medium containing glucose, fructose (reducing sugars), and sucrose as substrate. A factorial experimental design allowed for determining the optimum carbohydrate concentration. The synthesis in orange juice was carried out by adjusting the sugar concentration to the optimum found with synthetic media - sucrose (75 g/L) and reducing sugars (75 g/L), where reducing sugars were glucose and fructose in equimolar proportions. Magnetic and mechanic stirred-tank reactors at 25 (MAG25, MEC25) and 30 °C (MAG30, MEC30) for 24 h were employed using orange juice as substrate, and samples were taken at regular intervals. The final reducing sugar concentration decreased at 25 °C and increased at 30 °C. MAG25 resulted in the lowest sucrose concentration and favored dextran production. Sucrose was almost totally depleted at 6 h of processing with similar amounts of oligosaccharides for MAG25 and MEC25. Oligosaccharides with a higher degree of polymerization (DP) were produced at 30 °C, and low temperature led to the production of lower DP. The temperature was the more remarkable parameter. Although MAG25 and MEC25 were the best conditions to synthesize oligosaccharides and dextran in orange juice, MEC25 is more suitable and feasible for large-scale production. The oligosaccharides produced in orange juice were resistant to simulated digestion and consumed by the human colonic microbiome, resulting in a higher relative abundance of beneficial bacteria.

Food performances, properties, digestibility & functionalities

Poster

Cell Wall Composition Modulates Gut Microbiota and Short Chain Fatty Acid Production during IN-vitro Fermentation

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Cereals, legumes and tubers are dominant staple food in human population of different agro-climatic zones and geographic location. Their cell wall is an important source of dietary fibre. Dietary fibres like plant cell wall pass through the upper digestive tract intact and is available for lower gut microbiota utilization and modulation of gut environment. Depending on different botanical sources, the polysaccharide and monosaccharide compositions of cell walls vary. To understand how different type of plant cell walls affect gut microbiota fermentation otucomes, cell walls from three different types of cereals (barley, sorghum and waxy rice), legumes (pea, faba bean and mung bean) and tubers (potato, sweet potato and yam) were isolated and subjected to in-vitro human faecal fermentation. Analysis of cell wall composition revealed significant differences among cereals, legumes and tubers. Cereal cell walls were high in xylose, legume cell walls had high content of arabinose and tuber cell walls were rich in galactose. This difference was reflected on varying fermentation profiles of these substrates. Cereals cell walls degraded slower than other groups, with low short chain fatty acid production. Moreover, microbiota composition of different types of cell walls changed after 48 hours in-vitro fermentation. The research suggested that the cell wall composition is determined by the plant botanical source, and the different polysaccharides, as well as the different monosaccharide content, could determine both fermentation outcomes and microbiota community shifts.

Poster

Lactose in Dairy Powders - from Crystal Size to Powder Functionality

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Dairy powders are an excellent source of high-quality protein, essential in the nutritional intake of children in the developing world. Challenging environmental conditions can result in detrimental quality losses. Lactose should be in the glassy state to ensure good functional properties. However, transportation and storage conditions can exceed critical relative humidity (RH) and temperature (T), resulting in the glassy amorphous lactose transforming into a rubbery amorphous and eventually crystalline state with detrimental effects on quality. There is currently a knowledge gap in understanding the nature of crystalline lactose formation - e.g. phase, size, and crystallization-kinetics – for (complex) dairy systems.
We exposed a fat filled milk powder at five RHs, from 22.5% to 75.3%, and two Ts (25°C and 40°C) for 4 months. The functionality, i.e. reconstitution and colloidal stability, was investigated. Surface morphology, chemistry and lactose crystallization were characterized using SEM, FTIR, XRD and DSC.
Powders stored at RH 22.5% reconstituted into stable colloidal systems, irrespective of the storage temperature. XRD indicated that lactose remained amorphous under these storage conditions. For the other samples, powder wettability and colloidal stability were reduced. When increasing RH and T, crystallinity of lactose increased, leveling to approximately 50%. The anhydrous phase mixture of β-lactose and α-lactose dominated in powders stored between 40.0% to 57.7% RH. Only α-lactose monohydrate was observed at 75.0% RH. The crystal size increased from nanometers to micrometers by increasing RH and T, in an opposite fashion to wettability and colloidal stability. Our study demonstrated that the transition of amorphous to crystalline lactose in complex dairy powders is not necessarily harming reconstitution-performance for the stored powders or colloidal stability. The results indicate that for dairy powders, phase and size of lactose, rather than total crystallinity, are key in controlling functionality.

Poster

Ora-pro-Nobis protein techno-functional properties evaluation for developing new food ingredients

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The Pereskia aculeata Miller, commonly called by Ora-pro-Nobis (OPN) is a non-conventional plant, native from South America that has unexplored potential. Their leaves have been gaining recognition due to their protein amount (19.6 - 26 %), being popularly known as "meat of poor". Therefore, the aim of this work was to evaluate the physical-chemical composition and techno-functional properties of OPN protein. The zeta potential and protein solubility were determined as a function of pH (2 to 10). Emulsion activity index (EAI) and emulsion stability index (ESI) were determined in sunflower oil/water emulsion with different protein concentrations (0.25, 0.50 and 1.0%). Furthermore, the foaming capacity (FC) and foam stability (FS) properties of OPN protein were also investigated. The solubility and zeta potential were correlated and the isoelectric point (pI) observed was around pH 2. The results showed that an increase in pH (pH 8.0) enhanced the protein solubility by almost 15% when compared to pH 6.0. The OPN protein solubility observed was lower than soy commercial protein, however, it is still higher than pea and wheat commercial protein at the same pH and concentration. At the lowest protein concentration (0.25%) it was observed an increase in the effect on the EAI (10.65 m^2/g). In addition, at the highest concentration (1.0%) the EAI supprimed diminished (EAI =4.26 m2/g), which is probably due to the saturation of the oil interface by the proteins. The ESI varied from 46.08 to 73.91 min, by increasing the protein concentration. The FC was 50.0% and FS was 51.04% for 30 minutes and 38.40% for 60 minutes. Overall, the results indicated that OPN protein could be a great alternative for developing new food ingredients used in a wide range of food products including that plant-based.

Food performances, properties, digestibility & functionalities

Poster

CAROB PROTEIN HYDROLYSATES AS STABILIZING AGENT IN O/W EMULSIONS

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Hydrolysis can improve the techno-functional properties of several proteins, especially those of plant source that have poor performance compared to animal proteins. In this context, the objective of this work was to evaluate the techno-functional properties of carob protein hydrolysates (CPH) aiming their application as stabilizing agent in O/W emulsions. Carob protein concentrate (CPC) (53% of protein) was hydrolyzed by protease from *Bacillus* sp. to a degree of hydrolysis of 2%. CPC and CPH were evaluated for solubility, zeta potential and antioxidant capacity (ABTS+ and DPPH assays). In addition, the emulsifying properties of O/W emulsions stabilized by CPC or CPH (5% of protein, and 10% of linseed oil, w/w) were evaluated from different parameters as emulsifying activity (EAI), emulsion stability index (ESI) and emulsion stability (backscattering profiles). Enzymatic hydrolysis doubled the protein solubility over a wide pH range (2 to 10), reaching a maximum value at pH 10 (12.12±0.18% and 26.12±2.60% for CPC and CPH, respectively). Hydrolysis process did not affect the zeta potential of the samples, which ranged from 6.52±0.68 to -25.35±2.32 mV for CPC and from 4.79±1.23 to -24.30±1.88 mV for CPH, at pH values from 2 to 10. In addition, the isoelectric point of ~3.5 was found for both protein samples. Antioxidant capacity after carob protein hydrolysis increased from 1,083±10 to 1,243±93 mmol TE/g of protein for the capture of the ABTS+ radical; and from 1,456±10 to 1,684±121 mmol TE/g of protein for the capture of the DPPH radical. There was a slight increase in the EAI when CPC was hydrolyzed, from 5.60±0.21 to 6.06±0.11 m2/s. No effect of enzymatic hydrolysis on the ESI values was observed, which was 236±19 min and 251±25 min for the CPC and CPH, respectively, indicating that both emulsions presented a similar stability. This behavior was confirmed by stability analysis, in which both emulsions showed considerable destabilization after 1h. These results indicate that although hydrolysis did not improve the emulsifying properties of carob protein, an increase in solubility and antioxidant capacity facilitates its application in food products, especially those susceptible to oxidation.

Food performances, properties, digestibility & functionalities

Oral

Development of encapsulated plant-based extracts rich in phenolic compounds with high antioxidant activity for their incorporation into legume flours

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Nowadays, there is an increasing trend in legume consumption as legumes are a rich and sustainable source of plant-based proteins with biological activities helping to reduce many health risks. In order this food's functionality to be enhanced, antioxidant ingredients with beneficial properties to human health, usually derived from plants, are incorporated. However, these components are unstable during processing and storage so their encapsulation into appropriate matrixes is crucial. The primary aim of this study was the recovery of antioxidant ingredients from oregano, rosemary and *Magnolia officianalis* plants and their encapsulation into stable structures for their incorporation into legume flours. The recovery of these bioactive ingredients was optimized using microwave/ ultrasound assisted extraction (MAE/ UAE) and a combination of them. The extraction parameters including MAE and UAE power, the solid: liquid ratio and the extraction time, were optimized using the response surface methodology (RSM) and central composite design (CCD). The antioxidant activity and total phenolic content of the extracts were evaluated. The recovered ingredients obtained at optimum conditions were encapsulated in natural polymers through electrospinning process and spray drying. The effect and optimization of the operating parameters in terms of encapsulation efficiency (EE) of the aforementioned methods was also studied using RSM and CCD. EE was measured through the determination of phenolic content and the presence of the antioxidant ingredients in the different structures was confirmed using the ATR-FTIR technique. The morphology of the obtained structures was characterized via SEM and the release rate of the encapsulated ingredients was determined over time under different storage conditions. According to the results of this research, antioxidant extracts from oregano, rosemary and *Magnolia officianalis* can be efficiently recovered and encapsulated via the studied methods. Furthermore, the final encapsulated structures can be effectively incorporated into food systems, thus leading to the production of high-standards novel legume flours in terms of their bio-functional characteristics.

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Food performances, properties, digestibility & functionalities

Poster

Food Texture Modifications for Dysphagia Patients

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Nowadays, the elderly population is growing rapidly in many parts of the world. A common problem with the elderly is choking while eating. However, elderly people often have Parkinson's disease, a neurological disease. Globally, the prevalence of Parkinson disease (PD) has doubled in the past 25 years with global estimates in 2019 showing over 8.5 million individuals living with PD. In addition, 82 percent of Parkinson's patients suffer from choking and swallowing problems. Food choking is also the primary cause of increased risk of lung infection, and it is also the first cause of death of Parkinson's patients. However, the swallowing ability of patients can be improved by training under the supervision of rehabilitation medicine. A suitable diet for dysphagia patients recommended by the National Dysphagia Diet (NDD) standards must be a soft, slippery, non-watery gel to prevent choking and clogging of the throat. However, a ready-to-eat diet suitable for dysphagia patients is not yet available in the market. Thus, the objective of this research was to produce ready-to-eat food for Dysphagia patients by using agar, carrageenan, gelatin, xanthan gum, and konjac glucomannan at different concentrations to modified food texture for practice swallowing ability and consume in daily life. In this experiment, the texture modified food was analyzed for viscosity, texture profile analysis, color, pH, syneresis, and total microbial count during storage to predict shelf life. The results indicated that the texture modified food containing 1%w/v of carrageenan had a suitable texture characteristic for 1st and 2nd level by NDD standards patients. Storage of the sterilized samples at room temperature for 9 weeks showed a decrease in hardness and viscosity, an increase in brownness, but no change in adhesiveness, springiness, cohesiveness, pH, and total microbial count. In addition, samples showed no syneresis throughout the storage period.

Food performances, properties, digestibility & functionalities

Poster

Relationship between ?-glucosidase and endogenous enzymes in milled rice on suppressing retrogradation in cooked rice starch

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After rice is cooked at a rice-processing plant and before it is eaten by the consumer, there is time during which its texture and appearance can deteriorate because of the retrogradation of the rice starch. We previously reported that adding α-glucosidase (AG) before cooking rice can reduce the retrogradation of cooked rice starch. However, the mechanism of this reduction in retrogradation is not clear. The present study investigated the influence of the soluble monosaccharides and oligosaccharides released from the enzymatic reactions of AG and endogenous enzymes in milled rice on reducing retrogradation.

Hitomebore rice, produced in Japan in 2021, was used for this study. Its starch was extracted by the cold alkali method. The crude enzyme was extracted from the rice using a concentrated extraction buffer solution consisting of 1 M sodium malate, 1 M sodium chloride, and 40 mM calcium chloride. The activities of AG and the endogenous enzymes were measured using p-nitrophenyl α-D-glucopyranoside (PNPG) as the enzymatic substrate. The rice starch was mixed with AG and/or endogenous enzymes and water and then heated. The amounts of soluble saccharides released from the rice starch during heating were measured by HPAEC-PAD (high-performance anion-exchange chromatography/pulsed amperometric detection).

The optimal temperatures for the activities of AG and endogenous enzymes were 65 and 50?55 °C, respectively. The amounts of soluble saccharides released from the rice starch confirmed that little saccharide had been released due to the AG enzymatic reaction. Thus, AG might not act directly on rice starch. However, the amounts of glucose and maltose released from the sample with both added AG and endogenous enzymes were higher than the total amounts of released from the sample with added AG and from the sample with added endogenous enzymes. From the results of enzymatic activity measurements, the sum of the activities both of AG and endogenous enzymes equaled to the activity of the mixture of AG and endogenous enzymes. In conclusion, endogenous enzymes first hydrolyzed the starch then AG further hydrolyzed the hydrolyzed products, thus increasing the total amount of soluble saccharides and reducing the retrogradation of cooked rice starch.

Food performances, properties, digestibility & functionalities

Poster

Valorization of brewing industry wastes: Proximal and functional characterization of malted barley (Hordeum vulgare) bagasse meal.

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The main solid input for brewing beer is malted barley. After brewing, the main by-product generated (approximately 85% of the total) is the spent grain (Brewer's Spent Grain - BSG). This by-product is frequently used for animal feed or discarded in landfills. It is estimated that up to 37 million tons per year are generated worldwide, representing a high potential for utilization according to its composition. This study determined and characterized the nutritional and antioxidant quality of malted barley bagasse meal from the production of craft beer in Colombia, with a view to the integral utilization of raw materials and the reduction of agroindustrial waste generation. The characterization of the by-product was carried out in accordance with the AOAC (Association of Official Analytical Chemists). The determination of antioxidant activity was carried out by implementing three quantitative methodologies, TEAC (Trolox Equivalent Antioxidant Capacity), FRAP (Ferric ion Reducing Antioxidant Power) and ORAC (Oxygen Radical Absorbance Capacity). Regarding the proximal characterization of malted barley bagasse flour, it was found that its main macro compounds are fiber and protein with values of 74.0 % and 14.3 %, respectively, on a dry basis. With respect to antioxidant capacity, it was found that the flour presented results for TEAC of 2602.6 µequ Molar trolox per 100 milligrams of sample, with respect to FRAP activity, a value of 1823.1 µequ Molar trolox per 100 milligrams of sample was found, and for ORAC of 1057.8 µequ Molar trolox per 100 milligrams of sample. Based on the results, it can be concluded that the by-product obtained after the craft beer brewing process presents in its composition mainly insoluble fibers and soluble proteins; with respect to antioxidant activity, malted barley bagasse flour presents relatively high values compared to similar by-products of the food industry. According to the results, it is recommended to explore the use in food matrices rich in fiber and/or enzymatic hydrolysis of proteins to obtain peptides with higher antioxidant activities.

Food performances, properties, digestibility & functionalities

Poster

Contribution of the biological healthy potential of hydrophilic co-extracted compounds other than betalains and phenolics of green extracts from Opuntia spp. fruits

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The Opuntia spp. prickly pears are fruits, which provide a great source of betalains (mainly, betacyanins) and phenolic compounds (phenolic acids and flavonoids) that could play an important role in health-promotion. In this work, the contribution of coextracted hydrophilic compounds, such as carbohydrates and vitamin C, to biological activities (antioxidant, antiglycemic and anti-inflammatory) in green extracts from different tissues (whole fruits, peel and pulp) of Opuntia ficus-indica (var. Colorada and Blanca) and Opuntia stricta var. Dillenii fruits. The Opuntia fruit green extracts were obtained by ultrasound-assisted extraction (UAE) using green solvents such as ethanol and water. The Opuntia green extracts obtained by this process were rich in betalains and phenolic compounds but also they contained significant amounts of carbohydrates and other compounds such as ascorbic acid that also contribute to the observed biological activities (antioxidant, antiinflamatory and antihyperglucemic). In this work, the cleaning-up of the Opuntia green extracts with silica C18-RP chromatography, and the analysis of their chemical composition and biological activities of the obtained fractions was evaluated. In addition, the correlation between these assayed biological activities with the chemical composition (mainly betalains, phenolic compounds, carbohydrates and vitamin C) of each obtained clean-up chromatographic fractions were studied.
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Food performances, properties, digestibility & functionalities

Poster

Looking for a compromise to supplement beef burgers with fava bean (Vicia fava) flour

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Plant-based proteins are rapidly becoming mainstream ingredients for the rapidly growing global population (Mintel, 2013). Their use in restructured beef products has increased in the last years due to its ability to improve cooking yields, water/fat binding capacity, and sliceability (Baugreet et al., 2019). Additionally, plant-based proteins must contribute to the nutritional and sensorial characteristics of the final product. In this sense, some undesirable effects, such as the perception of bitter and astringent tastes or grassy and beany notes, have also been observed on the organoleptic profile of meat products when plant-based proteins were used (Peng et al., 1982). Thus, this work aimed to evaluate the level of burgers supplementation with fava bean (Vicia fava) flour to avoid an undesirable effect on their sensory properties. Beef burgers were supplemented with different amounts of flour: 0, 10, 15, and 20% (w/w) and cooked for core temperature 70°C. To test the sensory acceptance of the final product, a trained panel composed of 5 judges, whose ages ranged between 20 and 60 years-old, tested the burgers presented in a random order. Tests were run on a 9-point hedonic scale (1 = dislike very much, 9 = like very much) (UNE-ISO 4121:2003). The following sensory parameters were evaluated: flavour, tenderness, and juiciness; due to their relevance on the supplemented products. Each sample was given to panellists at room temperature and was coded with three arbitrary numbers. A one-way ANOVA test, followed by Tukey-Kramer post-hoc test, was performed to evaluate differences among samples and were considered statistically significant at $p < 0.05$. Results showed that the supplementation of beef burgers with 10% of fava bean flour did not alter samples' flavour and tenderness compared to the control burger, whereas juiciness was significantly ($p < 0.05$) different. Remarkably, samples containing 15% and 20% of fava bean flour scored significantly ($p < 0.05$) lower for the juiciness attribute, negatively affecting food perception. Hence, these results indicate that supplementing restructured beef products with 10% (w/w) of fava bean (Vicia fava) flour allow reducing the level of animal protein without having any adverse organoleptic effect.

Food performances, properties, digestibility & functionalities

Poster

Intragranular distribution of inhibitory effect on retrogradation in cooked rice grains achieved from addition of ?-glucosidase (AG) and branching enzyme (BE).

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Retrogradation of cooked rice progresses over time, and hardens the rice, causing a parched texture, so controlling this retrogradation is an important issue. The main factor contributing to rice retrogradation is recrystallization of starch in gelatinized rice. Adding α-glucosidase (AG) or branching enzyme (BE) when cooking the rice was found to inhibit retrogradation. We previously established a method utilizing X-ray diffraction to quantify the degree of starch retrogradation. In this study, we investigate the intragranular distribution of the inhibitory effect obtained from AG and BE on starch retrogradation by measuring X-ray diffraction at different sites on the cooked rice grain.

Rice was cooked and stored at 15 ? for two days. The sample was made by slicing a rice grain near its lengthwise center, perpendicular to its longitudinal axis into a 1 mm-thick disc. Cyanoacrylate adhesive was applied to the sample surface to suppress moisture evaporation from the rice surface. X-ray diffraction was measured at 6 sites respectively by irradiating X-rays with a beam size of 100 μm toward the core from the sample cross-section surface using BL-5A beamline from the High Energy Accelerator Research Organization. The degree of starch retrogradation was then calculated from the X-ray diffractogram obtained using the 4a peak area.

Compared with an identical rice grain, the degree of starch retrogradation increased the closer to the core at up to 600 μm from the rice grain surface. From 600 μm, the degree of starch retrogradation declined the closer to the core, however, the starch retrogradation was not less than the surface starch retrogradation. The AG and BE-added sections showed less of starch retrogradation compared to the control sample at all measurement sites and the inhibitory effect on retrogradation from adding AG and BE was confirmed. When compared by site, the inhibitory effect on starch retrogradation achieved by adding AG and BE was greater on the surface than in the rice grain core. These results revealed that the inhibitory effect on retrogradation achieved by AG and BE was especially noticeable in starch near the rice grain surface.

Poster

Obtaining of Bioactive Hydrolysates from Protein of Californian Red Worm (Eisenia fetida) Through Enzymatic Hydrolysis and Crossflow Filtration.

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The objective of this study was to optimize the enzymatic hydrolysis of California red earthworm meat to obtain peptides with antioxidant capacity and it's scaled up from laboratory scale to bench scale, and then to separate it in 3 and 1kDa fractions in a membrane system of cross-flow filtration. The worms were manually separated, washed with water, purged for 4 hours with 4% sodium bicarbonate, then sacrificed using saline solution. The optimization of the hydrolysis used a spherical composite central response surface design with five points at the center using 4 factors, pH (7-9), temperature (40-60°C), substrate (100-200g) and alkalase enzyme (500-1500uL) and as response variables, soluble protein percentage (PP), degree of hydrolysis (DH), antioxidant capacity (AC) ABTS and FRAP, implementing a 7.5 L reactor. The procedure to achieve the dimensional analysis consists of three steps: Listing important variables, verifying dimensional homogeneity by transferring it to a dimensionless form and determining dimensionless Pi numbers from a transformation matrix, Pi theorem. Fractionation was performed using 7-channel membranes with molecular weight cut-off of 3 and 1 kDa. The optimal hydrolysis conditions are pH 8.5, temperature 45°C, with 125.01g substrate and 1243uL of enzyme, obtaining DH of 16.52%, PP of 3.38% and AC of 2055 and 170 umol-equ trolox/g protein for ABTS and FRAP, respectively. Additionally, the optimal hydrolysate has an ORAC of 823umol-equtrolox/g protein and iron chelation with IC50 at 150ppm. The dimensional analysis of the hydrolysis process from 0.5L to 7.5L showed that the dimensionless number for the scale-up is the Reynolds, the scaling was performed with geometric similarity modifying the impeller speed which went from 240 rpm in 0.5L to 122.45rpm in 7.5L. The purification of the peptides by means of the membrane system concentrated the proteins of the retained with respect to the initial fluid, while the concentration of the permeate is significantly lower compared to the original fluid, both in the 3 and 1KDa membrane. It is concluded that the enzymatic hydrolysate of Californian red worm has a high AC and a low IC50 in iron chelation, making it a substrate of interest for application in different industries.

Poster

STABILITY AND BIOACESSIBILITY OF NANOENCAPSULATED COENZYME Q10 IN YOGURTS

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Coenzyme Q10 (CoQ10) is an antioxidant essential for the mitochondrial electron transport chain. Although CoQ10 is naturally synthetized by human body, its production is reduced by ageing or genetic failure, requiring frequent ingestion through supplements or fortified foods. Due to its hydrophobicity and low bioacessibility, the successful incorporation of CoQ10 in food matrices depend on the application of strategies like the nanoencapsulation in lipid carriers. In order to verify the stability and bioacessibility of nanoencapsulated CoQ10 in yoghurts, Ynano Q10 (YQ10 - nanoemulsion developed by Yosen Nanotechnology, containing 5% of CoQ10) was incorporated in different concentrations (0, 1 and 7%, w/w) to commercial plain products. The samples were evaluated in different days of storage regarding CoQ10 concentration and color (instrumental colorimetry). Besides, the yogurts and YQ10 were subjected to in vitro digestion and subsequent CoQ10 quantifications. The results revealed a good stability of the encapsulated bioactive throughout 30 days of storage. The bioactive concentrations at 1st day of storage were 5.797% ± 0.178, 0% ± 0, 0.060% ± 0.0015 and 0.422% ± 0.047%, for YQ10, blank yogurt, 1% YQ10 yogurt and 7% YQ10 yogurt, respectively, while, at the 30th day were 4.582% ± 0.325, 0% ± 0, 0.047% ± 0.0041 and 0.314% ± 0.022. Regarding the colorimetric parameter chroma, at 1st day of storage the values were 40.63 ± 0.79, 4.83 ± 0.03, 9.30 ± 0.06 and 23.19 ± 0.11 for YQ10, blank yogurt, 1% YQ10 yogurt and 7% YQ10 yogurt, while at 30th day were 34.31 ± 1.18, 4.03 ± 0.01, 10.40 ± 0.13 and 22.59 ± 0.02. The values of Hue angle at 1st day were 79.14 ± 0.54, 107.74 ± 1.00, 102.75 ± 0.14 and 93.68 ± 0.07 for YQ10, blank yogurt, 1% YQ10 yogurt and 7% YQ10 yogurt, while at 30th day were 79.24 ± 0.60, 109.78 ± 0.32, 101.75 ± 0.68 and 94.82 ± 0.14. The results obtained after the in vitro digestion indicated the presence of bioactive even after the gastric and intestinal steps, revealing that the nanoencapsulation was not only effective in protecting the CoQ10 in yoghurts, but also in increasing its bioacessibility.

Poster

Textural, functional, and sensory characterization of low sugar gummies formulated with stevia (Stevia Rebaudiana Bertoni) and red fruits..

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The consumption of foods high in sugars and specifically sweets and gummies, represent a risk to the health of the people who consume them, because they can cause various diseases associated with cardiovascular problems and diabetes; In this sense, it is important to look for emerging raw materials that allow the development of healthier candies or gummies. In that order of ideas, red fruits such as blackberries and strawberries are rich in bioactive compounds which, when consumed, generate health benefits for human beings; In addition, Stevia, being a non-caloric sweetener, is an alternative to the use of sugar in the formulation of gummies. The main goal of this research was to develop gummies with berries and the addition of Stevia, as well as their characterization, as a nutritional and consumption alternative. The methodology included the formulation of a control gum which contained a percentage of red fruits of 18% in a ratio of blackberry/strawberry 70/30. Sugar was replaced by stevia at 15%, 20% and 30%. Moisture content, total phenols and ascorbic acid content of the gums were determined. Finally, textural, and sensory analyses were performed, the latter according to GTC 293/2018. The gummies with 20% stevia were the best formulation which reported an adhesiveness and hardness value of -0.01858 ± 0.0026 and 30.5726 ± 3.85 N, respectively. The sensory scores for flavor attributes and texture were 2.5, with 3 being the maximum score. Finally, moisture content, total phenols and ascorbic acid were 45%, 99.74 ± 0.9 mgAG/100g dry sample and 37.80 ± 0.94 mgAA/100g dry sample, respectively. In general, it can be concluded that it is possible to formulate a gummy with textural, proximal and sensory properties of its own, from red fruits and stevia, as a healthy consumption alternative for people.

Poster

Multiband Spectroscopic Evaluation of Soup Stock from Kombu

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Dashi (soup stock) is an essential part of Japanese cuisine. It is important to cook based on the characteristics of the dashi as well as the appropriate dashi for cooking. Regarding kombu (kelp)dashi, which is a typical type of dashi, the extraction temperature is an important factor in cooking as well as the characteristics of kombu. On the other hand, there are many examples of research on amino acids which are representative of umami components, regarding the characterization of kombu dashi, and there are few examples of research that considers the complexity of mineral components, which are thought to affect off-taste. This study aimed to get a good grasp of the influences of the extraction temperature on the extraction behaviors by measuring the glutamic acid concentration and the X-ray fluorescent, ultraviolet-visible and infrared spectra.
A freezer bag containing 1 dm3 of mineral water (hardness of about 30) was heated in a water tank of a low-temperature cooker (BONIQ Pro, Hayama-Colony inc.), and 30 g of cut kombu (1st grade, harvested in Toi, Hokkaido, Japan) was added into the mineral water after reaching the set temperature of 333 or 353 K. Additionally, the extraction was performed at 278 K using a constant temperature water bath. The dashi was sampled at the specified time until 60 min at 333 or 353 K and for 24h at 278 K, and the glutamic acid concentration and the multiband spectra were measured.
The acquired data presented that the extraction temperature affected not only the amount of the extracted components but also the balances of the extracted components and the kinetics. The dashi with different characteristics by changing the extraction temperature could be available even if the same kombu was used. By performing principal component analysis using the standardized values based on the characteristics of the dashi extracted at 333 K for 60 min, it was considered that the first and second principal components were respectively related to the extraction time and temperature. These results suggested the possibility to design the extracting the kombu dashi with different taste characteristics according to the multiband spectroscopic information.

Poster

Optimization of gluten-free flat bread formulated with dry fractionated pea protein concentrate, corn and rice flours

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Bread is a staple food, and flat breads are the oldest. The flat breads include a multitude of nuances, diversified by thickness, ingredients, process, and cooking methods. The flat bread market is increasing, with optimal previsions for the next years, also considering the gluten-free versions. Generally, gluten-free breads are characterized by a poorer nutritional composition and the use of additives to improve their acceptability. The use of legumes, nutritionally complementary to cereals, could contribute to their nutritional improvement.
The aim of this work was to develop a new gluten-free flat bread, “focaccia-style” (a traditional Italian flat bread, approximately 2.5 cm thick) formulated with rice and corn flour, fortified with a pea protein concentrate having 55 g/100 g protein content. The latter was obtained by a dry fractionation process, a sustainable technique to obtain vegetable proteins based on a physical separation, without wasting water or using chemicals.
Bread formulation was defined by simplex-lattice mixture design, which helped to study how the flours influenced the behaviours of dough and breads. Ten formulations were selected and their physical and sensory characterization was carried out, considering both dough and breads, to identify the best one. The optimal formulation was then characterized also from the nutritional point of view.
The properties of dough and bread varied among the ten trials, being significantly affected by the ratio of the ingredients. Flat bread added of 5% pea protein was identified as optimal. Its characteristics were: crumb hardness = 9.1 N, chewiness = 4.8 N, orangish color (a^* = 6.0, b^* = 31.8), moderate legume odor (5.6 c.u. in a 0-9 scale) and legume flavor (5.3 c.u.). The same bread could be labelled as a “source of protein” (>12% of the energy value provided by proteins), “source of fiber” (>3 g/100g of fiber), and “low-fat” (<3 g/ 100 g) food product, according to the EC Regulation No. 1924/06.
Considering the increasing interest in vegetable alternatives and the need to formulate nutritionally balanced and sensorially acceptable gluten-free flat breads, the use of pea protein concentrate, even at a reduced amount, demonstrated to be an effective and sustainable strategy.

Poster

Production of alginate microparticles to encapsulate soybean oil emulsions stabilized by whey protein aggregates using an airbrush atomization system

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The objective was to evaluate an encapsulation process of soybean oil emulsions stabilized by microgels entrapped in a sodium alginate (SA) matrix, using an airbrush atomization system.

Whey protein suspensions (4.3% w/w, pH 7.5) were thermally treated (80°C, 60 min) to produce soluble aggregates (WPAg), which were used to obtain stable microgel emulsions. These emulsions were mixed with SA suspensions to obtain different soybean oil volume fractions (Φ=0.17 and Φ=0.26). These mixtures were atomized at a flow rate of 4 mL min^{-1} over a 100 mM $CaCl_2$ gelling bath, with an air pressure of 276 kPa and air flow rate of 5 L min^{-1}. Microparticles were left for 30 min under stirring to complete gelation. To analyse the stability of microparticles, samples were poured into graduated glass tubes and centrifuged at 1,467 g and 25 °C for 15 min. The tubes were analysed to evaluate oil release. This procedure was repeated during 2 months. The particle size distribution was determined with a static light scattering instrument (refractive index for aqueous phase: 1.33, refractive index for microparticle phase: 1.507, absorption index: 0.1). The oil phase encapsulated inside the microparticles was extracted and correlated with the total oil volume atomized to estimate the encapsulation efficiency. Confocal laser scanning microscopy (CLSM) was used to study the morphology of microparticles. Samples were prepared with Nile Red and Fast Green to stain the oil phase and WPAg, respectively.

The results showed no differences in the size distribution curves between microparticles obtained with different oil fractions. The average D[4,3] and span values were 508.68±56.53 µm, 1.14±0.08 (Φ=0.17) and 526.78±51.12 µm, 1.19±0.06 (Φ=0.26). CLSM images showed microgel stabilized emulsion droplets are packed tightly with minimal interstitial space in both types of microparticles. The encapsulation efficiency in both cases was acceptable (89.39±5.48% for Φ=0.17 and 74.22±8.09% for Φ=0.26). None of the microparticles presented oil release after 2 months.

Results showed that emulsion microgel particles obtained by an airbrush atomization system can be an effective solution for lipophilic compounds. This system is simple, low-cost, and does not require heating, making it appropriate for labile compounds in the food industry.

Food performances, properties, digestibility & functionalities

Poster

Rheology of aerated buttercream icings

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Objective

Aerated icings are a fat-rich, sweet and uncooked type of glaze made by mixing powdered sugar and fat (e.g. butter, vegetable oil shortening) to form a bubbly fluid. An ideal aerated icing will exhibit viscoplasticity, flowing when the imposed stresses exceed a critical (yield) stress and retaining its shape otherwise.

Much research on bubbly liquid rheology has focused on systems with a Newtonian continuous phase. In aerated icings the continuous phase is non-Newtonian, with a relatively high critical stress, making it difficult to characterise in standard rotational rheometers.

Methods developed for dense suspensions (pastes) were used here to quantify the yielding, flow, and creep behaviour of aerated icings, and to determine how aeration determines these properties.

Methods

Aerated icings were prepared by mixing sugar and unsalted butter in the mass ratio 2:1 followed by whisking in a planetary mixer. The critical stress was studied using a controlled stress rheometer equipped with a vane tool to reduce wall slip effects. Extensional flow behaviour was studied by squeeze flow, using lubricated discs to reduce wall friction. The data were fitted to Herschel-Bulkley fluid models. The impact of replacing some of the butter by a concentrated native starch suspension to give a reduced fat product was also investigated.

Results

The icing air volume fraction, Ø, increased with mixing time, following the relationship , where the parameters and depended on mixing speed and mixer design. A simple mechanistic model for this behaviour is presented. Optical microscopy indicated that the bubble sizes were log-normally distributed with a modal value of approximately 10 µm.

The critical stress decreased with increasing Ø, as expected, but the dependency differed from existing models for bubbly liquids. The Herschel-Bulkley fluid parameters were also dependent on Ø. Noticeable deaeration occurred over a period of several hours, indicating that the continuous phase is not a perfect yield stress fluid.

Conclusions

The rheology of these aerated materials is controlled by the air volume fraction and hence determined by the aeration process. The observed behaviour can be quantified reasonably well by simple models based on physical processes.

Poster

ANTIOXIDANT AND ANTIMICROBIAL EFFECT OF STRAWBERRY TREE FRUIT WATER EXTRACT

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Strawberry tree (Arbutus unedo L.) fruit is widely distributed in the Mediterranean region. The fruit, because of its rich content of polyphenols, pectin and other polysaccharides is getting more interesting for functional food production. In local agricultural communities, this sweet but not very aromatic fruit is used for jams, marmalades and alcoholic beverages preparation. In this work, antioxidant and antimicrobial properties of strawberry tree fruit was investigated. For this purpose, cytotoxic and prooxidative/antioxidative effect of different concentrations of water extracts was determined (0.01-100 mg/mL, where 1 mg/mL and 10 mg/mL represented the recommended daily doses of polyphenols based on an average human weight and human blood volume, respectively). Human tongue carcinoma cells (CAL 27), colorectal adenocarcinoma cell line (Caco-2) and hepatocellular carcinoma cell line (HepG2) were used as biological test system. Protective role against hydroxyl radicals was determined on supercoiled plasmid model (φX-174 RF I). Antimicrobial activity against Staphylococcus aureus and Lactobacillus fermentum was also determined. Strawberry tree fruits, in the recommended daily doses, showed a proliferative effect on CAL 27 cells without and with 24-hour cell recovery, respectively. Antioxidant activity in CAL 27 cells was proven after 24-hour cell recovery, while prooxidative effect of A. unedo fruit has been shown in Caco-2 and HepG2 cells. It inhibited DNA damage caused by hydroxyl radicals in dose-dependent manner. This extract has shown antimicrobial activity against S. aureus, while it did not influence on L. fermentum survival. Further investigations are nedded to determine A. unedo fruit extract antioxidative potential.

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Keywords: A. unedo fruit extract, biologically active compounds, antioxidant effect, antimicrobial activity

Food performances, properties, digestibility & functionalities

Poster

Application of chickpea and sesame protein concentrate treated by transglutaminase in the formulation of a reduced-fat mayonnaise based on sesame oleosome

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Demand for low or reduced fat products has been increasing rapidly during the last two decades. Furthermore, sesame oil has been proved as a cholesterol lowering oil with several health benefits. In this research, oleosome of sesame seeds were produced after step-by-step milling and centrifugation process and the oleosome was characterised in terms of rheology and microstructure. Then the oleosome was used in the formulation of a reduced-fat mayonnaise with the final fat content of 45 %. Chickpea and sesame protein concentrates and their 1:1 mixture, post-treated by transglutaminase, were used as stabilizing agents. The fabricated reduced-fat product exhibited acceptable heat and physical stability in comparison with the standard samples. However, the stability was higher in samples containing sesame protein. This could be due to the smaller droplet sizes found by DLS measurements. Microscopic analysis also confirmed this observation and revealed that in samples containing chickpea protein aggregation of smaller particles could be detected. Rheometric analysis indicated that higher loss and storage modulus were obtained by the addition of sesame protein in comparison with chickpea protein, while zeta potential was lower for sesame protein containing samples. The results of this study indicated that a healthy reduced fat maionnase can be formulated by the application of sesame seed oleosomes and the product can be stabilised by the aid of sesame and chickpea protein.

Poster

Determination Of Some Physiochemical Parameters, Aroma Content, Antioxidant And Antibacterial Activity Of Anatolian Pine Honeys

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Honey is one of the world's most valuable foods for nutrition and diet. Due to the forest fires in Turkey in recent years, Pine Honey has become a type of honey that is rarer than ever before and its importance is well understood. The aim of this study was to investigate 10 different pine honey samples produced in different sub region of Western Mediterranean in Turkey regarding their physiochemical parameters, aroma content, antioxidant and antibacterial activity against five food-borne pathogens. For all honey samples, measurements were made according to European Honey Quality Criteria. Moisture content, pH value and free acidity averaged 17.5%, between 3.0 to 5.7 and 23.2 to 84.5 meq/kg, respectively. Electrical conductivity values ranged between 0.08 and 1.78 mS/cm, averaging 1.07 mS/cm. Hydroxymethylfurfural value was ranged from 35 to 50 ppm. All samples showed relatively low diastase activity. Fructose and glucose concentration was ranged from 35.7 to 40.5%, and 28.3 to 30.7%, respectively. The average value of accumulated H_2O_2 in 30% of honey solutions after 24 h was 2.3 µM and ranged from 1.2 to 4.4 µM. The average results for proline which has the most abundant free amino acid in different pine honeys mean ranged of proline from 20 mg/100g to 45 mg/100g. The total phenolic content was estimated to be 51 mg GAE/kg. The antioxidant activity by 2,2-diphenyl-1-picrylhydrazil (DPPH) of pine honeys was also measured ranged from 22.3 to 83.5%. The most abundant aromatic component in all of the pine honey samples was linalool with an average of 23%. Antibacterial activity of most common food-borne pathogens include Listeria monocytogenes, Salmonella Typhimurium, Staphylococcus aureus, Escherichia coli and Bacillus cereus was determined using MIC measurement in broth. Honey samples showed high antibacterial activity against all tested bacterial strains.

Food performances, properties, digestibility & functionalities

Poster

Simultaneous determination of nine high-intensity sweeteners in sweeties from the Brazilian market

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A method was established for the simultaneous determination of nine high-intensity sweeteners (HIS) in sweeties like jellies, puddings, jams and candies. Briefly, the samples were diluted in water, filtered and analyzed using ultra-high performance liquid chromatography coupled to tandem mass spectrometry to determine acesulfame potassium, sucralose, aspartame, rebaudioside A, neotame, saccharin, sodium cyclamate, stevioside and advantame. The chromatographic separation was achieved in an analytical column Poroshell C18 (2.1 x 50mm, 2.7µm) maintained at 40 ºC. A ternary mobile phase consisted of formic acid solution 0.1% (A) and acetronitrile:methanol 1:1 (v/v) acidified with 0.1% of formic acid (B) in gradient mode elution. The analytical method was validated and applied in 40 commercial samples of sweeties with partial or total sugar reduction, including two different batches of each product. For the analytes, except sucralose, the precision and accuracy were determined at the levels of 20 ng/mL (low), 100 ng/mL (middle) and 400 ng/mL (high). Precision (RSD%) was lower than 11.95% and accuracy was between 70.4% and 109.86%. For sucralose, precision and accuracy were determined at 200 ng/mL (low), 400 ng/mL (middle) and 600 ng/mL (high). Precision (RSD%) was lower than 14.88% and accuracy was between 72.16% and 119.28%. For the analyzed samples, it was observed the presence of at least one and at most four HIS in the formulations, with different concentrations for the different brands. For acesulfame, the concentration ranged from 1.30 to 71.69 mg/100g, for the saccharin from 1.04 to 25.67 mg/100g, sodium cyclamate from 1.53 to 39.72 mg/100g, sucralose from 1.11 to 100.18 mg/100g, aspartame from 1.27 to 457.45 mg/100g, stevioside from 1.95 to 6.18 mg/100g and rebaudioside A from 2.18 to 4.84 mg/100g. All samples tested showed levels within the limits allowed by Brazilian legislation. FUNDING: São Paulo Research Foundation (FAPESP) [Grant number 2021/02387-6] and Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) [Finance code 001] .

Poster

Application of antioxidant nanoparticles based on starch and the phenolic compounds from propolis extract in jelly candies

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Application of antioxidant nanoparticles based on starch and the phenolic compounds from propolis extract in jelly candies

Abstract
Propolis has health-beneficial properties attributed to its phenol composition. However, this natural compound has low water solubility, strong taste, and aroma, limiting its food applications. Recently, starch nanoparticles have been used to stabilize bioactive compounds like propolis. This research aimed to produce starch nanoparticles by anti-solvent precipitation and to apply these nanomaterials as natural additives in jelly candies. Starch nanoparticles based on cassava and potato starches were produced by anti-solvent precipitation. It was observed that the phenolic compounds from propolis extract can be stabilized during the production of starch nanoparticles, in this way, approximately 55% of phenolic compounds from propolis extract were loaded on the starch nanoparticles. The starch nanoparticles containing the phenolic compounds from propolis were characterized by antioxidant capacity, particle size distribution, water activity, and chemical bonds (Fourier-transform infrared spectra, FTIR). All starch nanoparticles had values oscillating between 15 and 18 g of gallic acid equivalent per g of propolis, indicating that these nanostructures have high antioxidant properties. Furthermore, all starch nanoparticles had particle sizes lower than 1000 nm and low water activity (< 0.4), suggesting that these materials can be considered as having high chemical and microbiological stability. FTIR spectra revealed that the phenolic compounds interact with the starch nanoparticles by means of hydrogen bonds. Jelly candies added of starch nanoparticles (1 and 2 %w/w) containing the phenolic compounds of propolis were well dispersed and they imparted a brown color to the food systems. The jelly candies containing the starch nanoparticles displayed antioxidant activity, this property can be preserved when the jelly candies were stored at a low temperature and relative humidity. This research reports for the first-time information regarding the application of starch nanoparticles containing the phenolic compounds of propolis in food systems.

Keywords: Bioactive compounds, nanoparticles, starch, gelatin.

Food performances, properties, digestibility & functionalities

Poster

Desirability-based optimization of bakery products containing pea, hemp and insect flours using mixture design methodology

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Simplex lattice design was used to design 15 sponge cakes formulations combining pea (PP), hemp (HP) and insect (IP) flours representing 15% of dough composition. Moisture, protein content, baking loss, specific volume, texture and cost of the 15 samples plus the control (0% added protein) were analysed. Results showed that the effect of PP, HP and IP on cake properties could be modelled with linear regressions (96.80% < R^2 < 99.96%). Ternary diagrams showed the effect of the combination of the three proteins in each response. The desirability function was used to obtain a multi-response optimization of the samples with maximum protein, maximum specific volume and minimum incremental cost. Sensory results of the 5 optimised samples showed that by combining 3.75% pea, 3.75% hemp and 7.5% insect it was possible to obtain a dairy- and egg-free sponge
cake without significant differences from the control with animal-derived proteins.

Poster

Formulation of submicron ternary complex encapsulates for delivery of curcumin

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Objective: The main objective of this study is to develop submicron ternary complexes as delivery vehicle for curcumin using biopolymer in order to improve the physicochemical stability, solubility, bioaccessibility and intestinal permeability of the curcumin.
Methods: The submicron ternary complexes were successfully formulated with 2-hydroxypropyl β-cyclodextrin (2-HβCD), pectin (Pec) and whey protein (WP) using modified spray drying process. Surface morphology, particle size, and poly dispersity index of submicron single (cur/2-HβCD), binary (cur/2-HβCD/Pec & cur/2-HβCD/WP) and ternary (cur/2-HβCD/Pec/WP) complexes were studied using scanning electron microscope (SEM) and Dynamic Light Scattering (DLS). Functional attributes and physical state of the submicron complexes were analysed using Fourier Transform Infra-Red Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC). Encapsulation efficiency and dissolution behavior for all the encapsulates were studied. Bioaccessibility of the curcumin from complex encapsulates was studied using in-vitro gastrointestinal digestion. Intestinal permeability of curcumin from complex encapsulates was evaluated using ex-vivo everted gut sac technique and engineered small intestinal system.
Results: The complex encapsulates cur/2-HβCD, cur/2-HβCD/Pec, cur/2-HβCD/WP, and cur/2-HβCD/Pec/WP had particle sizes of 424.5, 505.7, 531.6, and 769.5 nm, respectively and exhibited spherical shape with homogeneous size distribution. The encapsulation efficiency of cur/2-HβCD, cur/2-HβCD/Pec, cur/2-HβCD/WP, and cur/2-HβCD/Pec/WP was found as 69.22, 75.55, 77.20 and 86.47%, respectively. FTIR analysis showed that the ternary complexation was mainly formed by hydrogen bonding. DSC results revealed that curcumin exhibited amorphous state in complex formulation. Moreover, curcumin ternary complexes exhibited better dissolution behaviour and enhanced stability under in-vitro gastrointestinal digestion. Additionally, the ex-vivo intestinal permeability study by dynamic small intestinal system revealed that permeation of curcumin from ternary complex encapsulates had 1.7-fold higher than the unencapsulated curcumin.
Conclusions: Physicochemical stability of curcumin can be pronouncedly enhanced with ternary complex system developed by low temperature modified spray drying process and also stabilized with proteins and polysaccharides.

Food performances, properties, digestibility & functionalities

Poster

In vitro oro-gastro-intestinal digestion of pearl millet fortified 3D printed idli

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Objective:
This study focused on determining the glycaemic index of pearl millet flour fortified idli batter (80:20 %w/w) printed at optimum printing conditions (800 mm/min speed; 1.22 mm nozzle diameter; 360 rpm motor speed; 2 bar pressure; 40,100% infill) using integrated dynamic oral processing, stomach and small intestinal system ARK.
Methods:
The mastication conditions observed in the in vivo experiments are simulated in the in vitro dynamic oral mastication system. The in vitro bolus is then digested in stomach model and the gastric emptying kinetics were evaluated. The gastric digesta was then digested in dynamic small intestine system to estimate the glucose absorbance, from which the glycaemic index of the samples was estimated.
Results:
The oral mastication kinetics are affected by the compositional changes of idli. 3D printed idli had a higher total consumption time (1.30±0.30 chews/s) as compared to idli samples (1.10±0.25 chews/s). Fortified idli printed at 40% infill (98.62 ± 9.23 min) has shown higher gastric half emptying time as compared to idli (74.78 ± 8.25 min). The batter printed at 40% infill (73.33±3.56) has shown lesser glycaemic index than the control idli samples (96.80±5.5). This reduction in Glycaemic index can be attributed due to the complex internal microstructure of the batter printed with 40% infill.
Conclusions:
Utilizing 3D printing for food-to-food fortification has the potential to alter the shape of foods and their nutrient bioavailability. By studying the digestibility kinetics of foods in a dynamic oro-gastro-intestinal system and taking into account the dynamics of food breakdown at all phases, the prediction accuracy of nutrient bioavailability and glycaemic index estimation using in vitro simulators can be improved.

Food performances, properties, digestibility & functionalities

Poster

Kombucha: Composition and new substrates trends

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The population's awareness of healthy diets and habits has aroused a remarkable and growing demand for functional foods. Adoption of a better lifestyle depends on healthy eating, promoting quality of life and contributing to the prevention of degenerative diseases and extending life expectancy. The food industry, concerned with meeting market demands, seeks healthier alternatives. Motivated to invest in the development of nutritious and functional products. The functional food and beverage market is the fastest growing segment in the food sector, and fermented products are seen as great precursors in the intake of functional foods, and fermented beverages are protagonists in this market, highlighting kombucha. Although kombucha is well known, its chemical and microbiological parameters still vary according to the method of preparation, temperature, microbiological culture, concentrations and type of substrate used. In this study, we bring a broader view of new alternatives and the results show that there is a possibility of using and applying the kombucha culture in the fermentation process of unusual substrates, such as dairy raw materials, fruits, herbs and vegetables, in addition to the traditional tea, such as promising alternative. Research involving identified or new ingredients is needed to have a broad knowledge and characterization of kombucha. Since most research focuses on antioxidation activities and phenolic compounds in traditional beverages, other compounds can be found in kombucha beverages where substrates vary. We believe this article can stimulate further research related to kombucha.

Food performances, properties, digestibility & functionalities

Poster

Salt as a platform for multiple micronutrient fortification of food.

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Approximately a third of humanity suffers from "hidden hunger" - the effects of insufficient amounts of key micronutrients in the diet. While the modification of the diet is the desirable way of sustainably addressing this problem, it is a very slow and difficult process, as it involves education and changes in food production as well as key social customs. Food supplementation is useful as a short term health intervention, but it requires education and a medical infrastructure to ensuresafe dosing of added micronutrients, Food fortification requires no action by the consumer, it is cost effective and sustainable.
While there are numerous food vehicles that are on could be fortified with micronutrients, poor rural consumers, especially women, do not participate in the cash economy, and do not purchase any processed foods. Thus existing programs do not reach up to a billion people mostry in developing countries in Asia and Africa.
Unlike most staple foods, salt is almost universally processed, and essentially everyone buys or barters for salt. Salt is consumed at uniform, predictable levels, and therefore it is an ideal carrier that ensures compliance without danger of under or over dosing.
The Food Engineering Group of. the University of Toronto developed technology that produces encapsulated micronutrients in a form that matches grains of salt in terms of size and colour. the premix particles are then blended with salt at a 1:100 to 1:200 ratio to provide 30 to 100% of the daily requirement. The platform tecnology, based on extrusion and encapsulation can delived a wide range of micronitrients in a form that prevent interaction between the added micronutrients and does not affect the organoleptic properties of foods. Salt double fortified with iodine and iron has been succesfully tested with some 5,5 million school children and 60+ million consumers in India and resulted in very significant reduction in anemia.

Food performances, properties, digestibility & functionalities

Poster

Hydrolysate from rainbow trout (Oncorhynchus mykiss) raw material – a valuable source of multifunctional bioactive peptides

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Seafood side streams are abundant, sustainable and contain valuable bioactive peptides, lipids and polysaccharides with health promoting properties, which all together make them an excellent alternative ingredient source for the food and nutraceutical industries.

Even though seafood rest raw materials as a source of multifunctional peptides have already been reported in scientific literature, extraction of bioactive peptides from farmed fish and fish residues for non-communicable disease prevention, is currently underexplored. Therefore, the current study's aim was to fill this gap by identifying new multifunctional peptides isolated from rainbow trout (Oncorhynchus mykiss) which can be further used in high-value applications such as functional foods and nutraceuticals.

Rainbow trout raw material ("Hofseth AS", Ålesund, Norway), was used for enzymatic hydrolysis in the study. Hydrolysis was performed in 4-litre bioreactors at 50±2°C, adding 0.05 % papain and 0.05 % (w/w) bromelain enzymes.

A peptidomic investigation (using HPLC-MS/MS technique) was performed to display chemical composition of the trout hydrolysates and identify peptide sequences which are present in the hydrolysate mixture, as well as proteins to which each peptide belongs to. In addition, direct antioxidant activity of the hydrolysate by using a combination of ABTS, FRAP and DPPH assays, was measured.

The study has shown that trout hydrolysate exerts a multifunctional bioactivity through the ability of reduction of the oxidative stress induced by H_2O_2 in human intestinal Caco-2 cells, as well as inhibition of ACE and DPP-IV activities, respectively, suggesting antioxidant, hypotensive, and anti-diabetic effects. The results of bioactivity investigation indicated that trout peptide mixture is able to scavenge the ABTS and DPPH radicals, respectively. In addition, it increased the reduction of Fe^{3+} at Fe^{2+}. At cellular levels, the same peptides reduce oxidant stress induced by H_2O_2 in Caco-2 cells.

The high presence of hydrophobic peptides within the hydrolysate is correlated to the antioxidant effect and other biological activities. Indeed, it was observed that the peptide mixture can reduce with a dose-response trend both ACE and DPP-IV activities, suggesting hypotensive and anti-diabetic activities of the hydrolysate.

Food performances, properties, digestibility & functionalities

Poster

Potential consumption of probiotics, prebiotics and symbiotics to strengthen the immune system in times of pandemic

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In recent years, the growing concern with health and the prevention of chronic non-communicable diseases has become the focus of interest as a research and technology public health problem. The consumption of probiotics, prebiotics and synbiotics modulates the immune system by reestablishing the gastrointestinal balance, which implies a better response of the immune system to combat COVID-19, in this framework changes in eating habits and lifestyle are providing a better quality of life and preventing diseases and strengthening the immune system. In this virtue, the concept of functional foods is born designed with components that affect physiological functions of the organism in a specific, positive and intense way. Within the range of functional foods are prebiotics, probiotics and synbiotics. The objective of this work is to analytically review the potentialities of the functional properties in the consumption of probiotics, prebiotics and synbiotics to strengthen the immune system for times of pandemic. A review of case studies, systematic reviews, original articles was carried out through the digital databases of PubMed, Science Direct, Springer, Elsevier and Google Scholar. Probiotics are live microorganisms that, when incorporated as a supplement in the diet, benefit the development of the microbial flora in the intestine. Prebiotics are non-digestible foods that promote the growth of bacteria in the colon. Lastly, synbiotics combine the association of prebiotics and probiotics in their formulations, which allows the benefits of this association to be taken advantage of more. The scientific case literature shows that people with an altered microbiota are more susceptible to COVID-19, therefore, probiotic supplementation improves the ability of the gastrointestinal microbiota to modulate immune activity. It has also been shown that patients who consume foods with a high content of prebiotics have a lower risk of complications from COVID-19 and a better post-illness recovery. Regular consumption of prebiotic, probiotic and synbiotic foods can be used in the treatment and prevention of pathological diseases and the regulation of the function of the body's defense system in times of pandemic.

Food performances, properties, digestibility & functionalities

Poster

Enrichment of bakery model foods with antioxidants from Mediterranean red fruits: a physicochemical study

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Incorporation of naturally derived bioactive compounds into new food products has been a concept with rising popularity in the food industry; supplementation with antioxidant-rich formulations has been proposed for the enhancement of staple food nutritional profile and shelf life.
In this study cherry and sour cherry formulations were used for the enrichment of model bakery products; the physicochemical, rheological and textural properties of the dough and bread as well as the antioxidant profile and sensory attributes of the final product were evaluated. Six different fruit formulations were used for the fortification, based on fruit powder, aqueous-ethanol fruit extract, lyophilized fruit extract and their combinations; alongside, the effect of two different raising agents (yeast and baking powder) was comparatively assessed.
Enrichment source (cherry or sour cherry) significantly affected dough pH values under both raising conditions; depending on the fruit acidity differences were observed, revealing pH variations of more than one unit.
During proofing time the presence of ethanol negatively affected swelling of yeast-prepared doughs, as opposed to baking powder ones. In the absence of ethanol yeast-prepared breads had better organoleptic characteristics (taste, texture, odor), which were significantly correlated with swelling ability. Acidification was noticed for samples with yeast activity, which was reflected by swelling increase. Color parameters (L*, a*, b*, ΔE) were highly associated with total phenolic and antioxidant content. Enriched samples presented significantly lower values of lightness and higher values of color difference (ΔE) compared to control.
Rheological and textural properties were significantly affected by the enrichment type and raising agent used. Baking powder formulations demonstrated elevated hardness, viscosity, storage and loss modulus values than yeast ones. Ethanol presence and acidity (pH) affected texture and rheological parameters of the dough.
This study highlights the importance of incorporating natural phenolic compounds from red fruits in model bakery products as an efficient means for increasing their nutritional value in terms of bioactivity. Moreover, this study outcomes point to the promising results of the direct use of extracts in baking powder-based formulations.

Poster

Determination of combined effect of commercial organic acids on the microbial quality and shelf-life extension of buffalo meat sausages

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The study was conducted to determine the impact of organic acids on buffalo meat sausages' microbial profile and shelf-life stability. Control, 0.75 % (T1), 1% (T2), and 2% (T3) (v/v) lactic acid and the acetic acid combined solution were prepared and sprayed on buffalo meat sausages. Total viable count (TVC), E. coli count, Pseudomonas count, water activity (aw), pH, and sensory evaluation were studied at 0, 4, 8, and 12 days. The data was analyzed through factorial ANOVA. In T2 and T3, 2.78 and 2.81, log10 CFU/g reduction ($p<0.05$) in TVC, while 1.38 and 1.46 log10 CFU/g E. coli reduction ($P<0.05$) was detected at the end of the storage. The significant Pseudomonas count reduction ($p<0.05$) was observed up to 2.21 and 2.45 Log10 CFU/g in T2 and T3. There was no significant difference ($p>0.05$) in pH and water activity (aw) between the different trials, but it was statistically different ($p<0.05$) from the control. The overall acceptability score was higher ($p<0.05$) in T1 and T2 than in T3. In conclusion, adding a 1% combined lactic acid and acetic acid (T2) significantly affected microbiological and physicochemical properties. The study will help to promote the combined application of organic acids for the shelf-life extension of buffalo beef sausages.

Food performances, properties, digestibility & functionalities

Poster

Influence of Soy Protein Concentrate Inclusion on the Physicochemical, Microbial and Sensory Attributes of Beef Patty during Chilled Storage

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In recent years, as the regular change in consumers' purchasing decisions for low-cost ready-to-eat meat products with high nutritional value and good eating quality increases, plant protein is used as an extender in ground beef formulations. Four different formulations with concentrations of 10, 15, 20, and 25% (w/w) of rehydrated soy protein concentrate (SPC) with the ratio of 1:2 (SPC: distilled water) added into beef patties were formed and stored at 4±2oC for 1, 3, 5, and 7 days. This study evaluated the effect of soy protein concentrate (SPC) on pH, color, WHC, cooking loss, cooking yield, TBARS, and microbial analysis of these formulations with a raw beef patty taken as a control. The addition of SPC didn't significantly affect the moisture loss during storage time ($p \geq 0.05$), whereas instrumental color, cooking loss, cooking yield, and water activity were significantly affected by SPC level and storage days ($p \leq 0.05$). The addition of SPC significantly increased Lightness (L*) and yellowness (b*), and redness (a*) decreased ($p \leq 0.05$) while the L*, b*, and a* decreased throughout the storage period ($p \leq 0.05$). Increased SPC levels resulted in high pH, greater WHC, water activity, cooking yield, and lower cooking loss ($p \leq 0.05$). The shrinkage in diameter was lower in all SPC-added patties ($p \leq 0.05$). Significantly lower lipid oxidation was recorded as the SPC level increased ($p \leq 0.05$) while lipid oxidation increased over the days ($p \leq 0.05$). The microbial count increased with the SPC level, and a similar trend of increment was found over storage days ($p \leq 0.05$). SPC addition improved textural properties ($p \leq 0.05$). The burger patty containing SPC 25% got higher scores for texture, juiciness, mouthfeel, and overall acceptance, among consumers, compared to all other treatments. SPC addition in patties positively impacted physical, textural, and sensory attributes preferred by consumers.

Food performances, properties, digestibility & functionalities

Poster

Evaluation of the polyphenol profile of jabuticaba peel flours by FTIR analysis

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Jabuticaba (Plinia sp.) is a Brazilian fruit, and its dark peel is a source of bioactive compounds, especially polyphenols. However, little is known about how much the content of these compounds may vary between jabuticaba samples, given that native crops tend to have a more dissimilar composition, influenced by environmental conditions. Robust analysis methods such as high performance liquid chromatography (HPLC) are expensive and time consuming, and Fourier-transform infrared spectroscopy (FTIR) spectroscopy together with chemometric models may be a simpler and reliable strategy for routine analysis. The objectives of this work were to evaluate the composition of polyphenols in jabuticaba peel flour (JPF) from different provenances and employ FTIR together with chemometrics to predict the polyphenol profile. Twenty eight flour samples (JPF) were produced by drying, milling and sifting jabuticaba peels. The main phenolic compounds were quantified by HPLC. The samples were also analyzed in a FTIR-ATR Spectrophotometer. The main compounds identified in the JPF were cyanidin-3-glucoside (C3G) (ranging from 352 to 1009 mg/100 g), ellagic acid (EA) (164 to 335 mg/100 g) and delphinidin-3-glucoside (D3G) (95 to 203 mg/100 g). PCA analysis indicated that samples were separated into two groups according to phenolics (PC1) and anthocyanin /EA (PC2) contents. EA presented a moderate correlation ($r = 0.69$; $p = 0.00$) with the content of total extractable phenolics, as opposed to C3G ($r = 0.45$; $p = 0.02$) and D3G ($r = 0.48$; $p = 0.01$), confirming that the Folin-Ciocalteu method is not selective for anthocyanins. In the FTIR spectra, two bands commonly found in phenolics were identified: 1390-1330 cm-1 and 1260-1180 cm-1, associated to interaction between O–H angular deformation and C–O stretching. Three PLS models were constructed. The best model was the one for C3G ($R^2 = 0.92$), followed by D3G ($R^2 = 0.87$) and EA ($R^2 = 0.83$). All models showed low calibration, cross validation and prediction errors, confirming the potential of FTIR and PLS for quantification of phenolic compounds.

Food performances, properties, digestibility & functionalities

Poster

Elucidation of starch recrystallization-induced quality changes in pre-cooked rice noodles under different storage conditions

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Pre-cooked noodles with long shelf-life and cooking convenience have been recently receiving a lot of attention in the global food market. However, thermal treatments during preparation and their high moisture contents bring about critical quality losses during storage, that have not been systematically evaluated yet. Thus, the quality changes of the pre-cooked noodles made from rice flour were investigated in terms of thermal, tomographical, and water mobile characteristics. In particular, their physicochemical changes were monitored under different storage conditions (room temperature, refrigerated, and frozen) for 4 weeks. The T_2 relaxation time and signal amplitude of the pre-cooked noodles were prominently changed during the refrigerated storage, showing water syneresis from starch recrystallization. In addition, the texture properties were highly correlated with the results of water mobility, presenting higher hardness and lower extensibility. Furthermore, non-destructive tomographical analysis demonstrated higher structural density and thickness of refrigerated noodles, which were correlated with the microstructural images by SEM. In addition, the higher degree of starch recrystallization was thermally observed in the refrigerated noodles during storage, followed by room temperature. This result might provide more fundamental information on the quality changes of pre-cooked noodles during storage, probably contributing to the quality improvement of pre-cooked starchy food products.

Poster

Increasing bioactivity and bioaccessibility of isoflavones using Combined bioprocessing of soybean extract

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Soy isoflavones are considered important sources of bioactive compounds, but they are poorly absorbable, due to their large hydrophilic structures. Some biotransformation strategies have been used to convert the glycosidic form into aglycones, making them available for absorption. Objectives: This study evaluated the potential of enzymatic and/or microbial fermentation bioprocesses in soymilk extract before and after gastrointestinal in vitro digestion. Methods: Commercial β-glucosidase and a mix of commercial probiotics containing Lactobacillus acidophilus, L. casei, Lactococcus lactis, Bifidobacterium bifidum e B. lactis were used to biotransform soymilk extract. Isoflavone profile was quantified by HPLC-DAD, total phenolic content by Folin–Ciocalteu test, and antioxidant capacity by ORAC and FRAP. Results: Soymilk enzymatically treated (ET) followed by microbial fermentation (ET+F) resulted in the conversion of glycosylated isoflavones (6-fold lower than the control for daidzin and 2-fold for genistin) to aglycones (18-fold greater than the control for daidzein and genistein), besides to increase the total phenolic content (3.48 for control and 4.48 mg/ml ET+F) and to improve antioxidant capacity represented by the ORAC (120 for control and 151 mg/ml ET+F) and by the FRAP (285 for control and 317 µl/ml for ET+F) before in vitro digestion. Further, the digested ET+F samples resulted in a higher content of genistein (2-fold higher than control) and also an increase in the total phenolic content (2.81 for control and 4.03 mg/ml for ET+F) and antioxidant capacity by ORAC were greater compared to undigested samples. Conclusions: Microbial fermentation processing reflected positive effects, but de combination of ET followed by F presented a synergistic effect, suggesting the greater potential for both bioprocesses to contribute to functional, nutritional, and bioactive properties of fermented soy-based products.

Food performances, properties, digestibility & functionalities

Poster

A new oil-based-double emulsion microcarriers for enhance stability and bioaccesibility of betalains and phenolic compounds from Opuntia fruit green extracts

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In this work, two formulations based on double emulsions W1/O/W2 of different composition have been developed to efficiently encapsulate the green extracts obtained from Opuntia fruit tissues. These green Opuntia extracts are rich in betalains and phenolic compounds, what gives them a high potential biological interest. The study of the physical-chemical characteristics of the double emulsions obtained, their stability, and their encapsulation capacity of each individual compound of betalains and phenolic compounds present in the extracts has been carried out by means of HPLC-DAD coupled to a mass spectrometry detector (LCMS SQ 6120, Agilent) with an electrospray ionization (ESI). Likewise, the microscopy study of the double emulsions and their evolution during static gastro-intestinal digestion in vitro were conducted, evaluating the stability of the individual bioactive compounds during the different phases of digestion and their improved bioaccessibilities due to the protection produced by its encapsulation.
This research was funded by the Spanish Ministry of Science and Innovation, project number PID2020-118300RB-C21.

Poster

Formulation of a Healthy Ingredient using Papaya Carotenoid Enriched Vegetable Oils: A Preliminary Study to Improve Carotenoids Stability and Bioaccessibility with O/W Emulsions

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The aim of the present work was to improve stability and bioaccessibility of carotenoids from papaya Sweet Mary tissues using carotenoid-enriched vegetable oils (soybean oil, sunflower oil and MCT) to formulate oil-in-water (O/W) emulsions. The use of different concentrations of pectin (1%, 2% and 3%) and homogeneization conditions (time: 2, 3, 4 and 5 min; rpm: 9500, 12000, 14000 and 16000 rpm) and high pressure homogenization (HPH) at 100 MPa for 5 cycles, were evaluated to determine the optimal condition to formulate such emulsions. The standardized in vitro digestion INFOGEST methodology was used to evaluate the bioaccessibility of papaya carotenoids encapsulated by O/W emulsions. Microstructural studies (confocal and optical microscopy) of the obtained emulsions and during their in vitro digestion phases were carried out. Sunflower O/W microemulsions showed smaller mean particle size, higher negative ζ-potential and higher viscosity, than soybean O/W microemulsions. Particle size reduction in sunflower microemulsions favoured the bioaccessibility of papaya carotenoids, being lycopene the carotenoid with the higher bioaccessibility (71.4%), followed by β-carotene (18.4%), β-cryptoxanthin (15.0%) and β- cryptoxanthin laurate (7.2%). Similar bioaccessibility was obtained for β-cryptoxanthin (15.41%), β-cryptoxanthin laurate (3.54%), β-carotene (17.89%) and lycopene (64.09%) in soybean emulsions. These results highlight the potential of using carotenoid-enriched vegetable oils to formulate O/W emulsions to enhance carotenoids bioactivity by efficiently preventing their degradation and increasing in vitro bioaccessibility.
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Food performances, properties, digestibility & functionalities

Poster

in vitro digestion of a bread and cheese meal as dynamically and non-invasively investigated by Magnetic Resonance Imaging

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Background and objective: Magnetic Resonance Imaging (MRI) is a highly promising non-invasive approach for both in vivo and in vitro digestion researches as it can provide information on the status and amount of water and lipid protons throughout the enzymatic breakdown of food(s). These information can be used for spatially resolved measurements of multi-scale structural features and composition of simplified or complex food products. The combination of foods (bread, cheese and water) and the non-invasive monitoring of digestion both in vitro and in vivo are two innovative research fronts in this area.
Method: The meal consisted of bread and cheese (24% lipids, 33% proteins, and 43% carbohydrates) added with water, and using in vivo realistic boli particle size distributions (range: 0-5 mm). The erosion of large praticles, the hydrolysis of nutrients, as well as the creaming of lipids were studied by low-field MRI (1.5 T) using an adapted version of the semi-dynamic gastrointestinal INFOGEST protocol.
Results: Combining different MRI image modalities, it was possible to investigate separately several phases of the digesta, i.e. supernatant, large cheese and bread crust pieces, and the deposit of small fragments at the bottom of the vessel. Changes in their volume, NMR relaxation parameters and lipid amount were discussed together and related to variations in pH, enzymatic activity and composition.
Conclusions: Low-field MRI allows to monitor dynamically and non invasively the process of imbibition, creaming and erosion in bread and cheese particles of which largest size was initially in the order of a few mm. Further research is needed however to relate NMR parameters to the molecular size and pH.

Food performances, properties, digestibility & functionalities

Poster

Physical properties and diffusion of gallic acid through alginate-nanocellulose composite gels

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Physical properties and diffusion of gallic acid through alginate-nanocellulose composite gels

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Abstract

This research aimed to evaluate how the crystalline nanocellulose (CNC) as a composite material influenced the physical properties and the diffusion of gallic acid (GA), as hydrophilic polyphenol model, through the alginate (SA)-nanocellulose composite gels formed via ionic crosslinking. The combined SA-CNC solutions made from 1:0, 1:1, 2:0, 2:1, 2:2, and 2:3 solid-based ratio of sodium alginate-nanocellulose (SA-CNC) in final solutions were evaluated for viscosity, gel syneresis, dried gel rehydration properties, gel strength and stiffness, gel microstructure, and FTIR spectroscopy. The diffusion analysis was conducted by composite gel filtration method and the polyphenol diffused out from the gel was evaluated using the Folin-ciocalteu assay. It was found that the composite gel with the highest proportion of CNC reduced the gel syneresis (54.9%) and increased the gel rehydration capacity (94.0%). Composite gel with 2:1, 2:2, and 2:3 in SA-CNC ratio could significantly increase gel strength and stiffness, which indicated a tougher and tighter structure compared to the neat SA gels, with the 2:2 SA-CNC gel giving the highest gel stiffness. The SA-CNC combination altered the gel network structure and porosity on the gel fractal surface microstructure analysis. Furthermore, composite gel with 2:2 and 2:3 in SA-CNC ratio reduced the diffusion of gallic acid by 44.3% and 43% respectively from the gel. Therefore, it can be concluded that the incorporation of CNC as a composite material in alginate gels could improve the gel's physical properties and reduce the loss of GA from the gel.

Keywords: Alginate composite gels, Crystalline Nanocellulose, Gel physical properties, Gallic acid diffusion

Food performances, properties, digestibility & functionalities

Poster

Development and physical characterization of novel food-grade W/O emulsions stabilized by stearic acid and guar gum

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In a system with a comparable oil and water content, the creation of a W/O or O/W emulsion could depend on the emulsifier type, and the gelling/structuring agents used.
The objective of this research was to analyze the effect of the formula composition on the physical properties and stability of food-grade emulsions containing a similar amount of water and oil and to develop W/O emulsion systems to be used as hard fat replacer or as ingredient in vegetable creams, or spreads.
A D-optimal mixture design was selected and a special regression cubic model was chosen. Five independent factors were chosen: sunflower oil, water, a mixture of sorbitan oleate and soy lecithin as emulsifier (4:1 ratio), stearic acid, and guar gum. The ingredients varied in a restricted range: oil and water content from 40 to 55%, emulsifier system from 1 to 5%, stearic acid from 0 to 3%, and finally guar gum from 0 to 0.3%.
32 formulations, including 3 replications, come out and were characterized in terms of particle size distribution (PSD), apparent viscosity after preparation and physical stability over time.
29 out of 32 formulations were W/O emulsions, with PSDs varying from bimodal to unimodal and D4,3 values ranging from 8 to 150 µm. Almost all formulations behaved like shear-thinning fluids, differing in apparent viscosity values. The most stable formulations were those with the 0.3% of guar gum. Analysis of variance revealed that formulation significantly affected emulsion properties. The parameters significantly affected by the formulation were used as response variables in different regression models. Several PSD and rheological parameters were explained through a special cubic model for, highlighting that the components interact with each other. Linear models were used to explain physical stability in terms of Turbiscan stability index (TSI).
Different suitable W/O formulations were found, minimizing both D4,3 and TSI values, at different levels of the rheological parameters, through the desirability function. These findings may provide an effective strategy to regulate the structure of functional multiphase ingredients, such as multiple emulsions, and to design foods with enhanced nutritional value, eventually including bioactive compounds.

Poster

In vitro digestion of two age-tailored dairy products in the aging gastrointestinal tract

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For older adults (> 65 years old), undernutrition is a severe health problem that can impact the quality of life, induce or aggravate the development of diseases, and reduce life expectancy. Undernutrition can be defined as an inadequate intake of dietary energy and proteins combined with a low muscle mass. Diet-induced muscle mass and strength loss in older adults may be due to insufficient protein intake. Therefore, older adults need to increase the amount of high-quality ingested proteins, particularly foods rich in leucine, to promote muscle health. However, it is still unclear if changes in protein digestibility and absorption kinetics in old age may affect the anabolic effect of high-protein foods. The objective of this study was to investigate the in vitro digestion of two aged-tailored dairy products. A dairy dessert containing 10 % proteins and a spreadable cream cheese containing 24 % proteins were formulated with a ratio of whey proteins to caseins of 80 to 20 % (as opposed to milk, i.e., with a ratio of whey proteins to caseins of 20 to 80 %). This enrichment in whey proteins was used to increase the intake of branched amino acids, like leucine, to stimulate muscle protein synthesis in older adults. The rheological properties of these products were measured and related to their sensory properties (i.e., oral comfort) assessed by a panel of over 65 years-old subjects. Finally, the food matrix breakdown in the stomach and protein digestion have been studied with an in vitro digestion model adapted to the physiology of older adults. This new model results from an international consensus reached within the framework of the European project EAT4AGE in collaboration with the international research network INFOGEST. This study should improve our knowledge of the digestion of age-tailored dairy products in the aging gastrointestinal tract and help formulate innovative nutrient-dense food products that improve the bioavailability of proteins.

Food performances, properties, digestibility & functionalities

Poster

Effect of the addition of dry extracts of yeast (saccharomyces cerevisiae) and beer on the sodium content and sensory acceptance of a traditional Colombian sausage "chorizo"

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In the year 2021, approximately 41 million people in the world died from non-communicable diseases (NCDs), including blood pressure and cerebrovascular pathologies, caused by bad habits such as sedentary lifestyles, poor diet, and excessive consumption of foods with high sodium content. To mitigate the above, the WHO and PAHO have created plans for healthy eating and reduction of sodium consumption; in Colombia, Resolution 2013 of 2020 seeks to gradually reduce the sodium content in food. The objective of the present study was to evaluate the effect of the addition of two types of dry extracts: yeast (EL) and beer (EC), on the sensory acceptance of a traditional Colombian sausage. The methodology included the preparation of sausages with pork, vegetables and spices, as contemplated in NTC 1325 of 2008. In general, 5 sausage formulations were made, F1(0.6%EL), F2(0.9%EL), F3(0.6%EC), F4(0.9%EC) and F5BC (standard), for which the theoretical sodium content was determined by mass balance, taking into account the technical data sheets of the raw materials; finally, the sensory analysis was performed according to GTC 293 of 2018 and NTC 3930 of 2010 with a total of 60 untrained judges. As results, the sodium content for F1(0.6%EL), F2(0.9%EL), F3(0.6%EC) and F4(0.9%EC) was 394.65 mg/100g, 284.03 mg/100g, 392.17 mg /100g and 280.32 mg/100g, respectively; while for the standard (F5BC) the content was 629.02 mg/100g. Regarding sensory analysis, the formulation with the highest acceptance was the standard (F5BC), followed by F1(0.6%EL), F3(0.6%EC) and with less acceptance F2(0.9%EL) and F4(0.9%EC), the above with a confidence level of 95%. It can be concluded that it is possible to formulate a traditional Colombian sausage "chorizo" ??with different percentages of dry extracts of yeast and beer, complying with the values ??required in sodium by the current national regulations and the guidelines proposed by the WHO and PAHO, in relation to the decrease sodium content in foods; being an alternative for healthy meat products with good sensory acceptance.

Poster

Limited enzymatically hydrolyzed Pea Protein - Inulin interaction and gel forming properties

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Plant proteins are gaining significant attention as a potential alternative to animal proteins in many food and beverage products. In general, these proteins lack the physical and chemical properties of animal proteins. The overall objective of this investigation was to evaluate hydrolysis as an approach to changing the structural and functional properties of pea proteins.

Inulin is a neutral oligosaccharide and soluble fiber and has bifidogenic properties to promote gut health. By combining hydrolyzed pea protein and inulin, a functional food/ingredient can be investigated. A specific objective of this research was to explore the degree of hydrolysis and pea protein to inulin ratio needed for the optimum structural and functional properties.

Limited enzymatically hydrolyzed pea protein solutions (7.5%) were prepared using the enzyme Alcalase at three hydrolysis times (0/control, 3 and 6 mins). The pea protein hydrolysate to inulin (PPH:IN) ratios studied were, 0 (no inulin), 4:1 and 2:1. The gels were prepared within the Discovery HR-2 rheometer by heating at 85°C for 10 mins (to induce gelation), and cooling at 25°C for 10 mins. Following cooling, the gel properties were measured using amplitude, frequency and flow sweeps to characterize the viscoelastic properties of the samples.

The highest storage modulus value was observed for gels with a PPH:IN ratio of 4:1 and 3 mins of hydrolysis, and the lowest value was observed for control samples with PPH:IN ratio of 2:1. It was apparent that hydrolysis time controlled the ability of the gel to incorporate inulin and had a greater effect on gel strength, as compared to PPH:IN ratio. The gels (except control samples) were physical gels, with similar frequency dependence values, despite having significantly different storage modulus values. The steady shear flow sweeps demonstrated that viscosity decreased with an increase of shear rate for all samples, suggesting a shear thinning behavior.

Poster

Building dual-purpose ingredient by covalently conjugating quercetin to WPI

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The development of dual-functional ingredients has attracted expressive attention food, nutraceutical and pharmaceutical industries. To meet this demand, quercetin (QUE)-whey protein isolate (WPI) conjugates by free-radical grafting technique (pH4) and alkaline reaction method at different pH (pH 9, 10, and 11) were produced aiming to produce antioxidant-emulsifier compounds. All treatments utilized the same content of WPI (5 g/100 g of water) and QUE (0.03 mmol). WPI-QUE conjugates and native WPI were characterized by Fourier transformed infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), Folin-Ciocalteu reducing capacity (FCRC), and antioxidant capacity (DPPH and FRAP). WPI-QUE conjugates produced at pH 4, 9, 10 and 11 were named QpH4, QpH9, QpH10 and QpH11, respectively. To test their emulsifying capacity, oil-in-water (O/W) nanoemulsions were prepared by incorporating pomegranate seed oil (10% w/w) into an aqueous solution of conjugates, or native WPI (1% w/w) using a rotor-stator (T18, IKA) for 5 min at 14,000 rpm followed by homogenization in a microfluidizer (M-110Y, Microfluidics Co.) at 100 MPa, for three cycles. The O/W nanoemulsions were evaluated by droplet size and instability Index (iI). All conjugation conditions produced compounds with improved antioxidant activity; however, the method and reaction pH affected the conjugate characteristics. QpH4 and QpH9 showed lower solubility, larger particle size and higher antioxidant activity probably because there was a higher attachment of QUE to WPI promoting the dimerization of WPI. The conjugation with QUE altered the secondary and tertiary structure of native WPI, according to the results from FTIR and DSC analysis. These conformational changes facilitated the anchorage of the conjugates onto the interface. WPI-QUE conjugate-stabilized O/W nanoemulsions, except QpH4, showed smaller droplet sizes than that produced with native WPI. QpH4-nanoemulsions had larger diameter (~226 nm) because its pH was close to isoelectric point of WPI. Even though they had different droplet sizes, nanoemulsions stabilized by conjugates, except QpH4, and native WPI had similar instability Index (~0.35). In summary, the results showed that the conjugation by alkaline method at pH 9 was an efficient technique to produce dual-functional compounds, with improved antioxidant and emulsifying potential.

Food future, innovation in teaching and learning, innovation and management

Oral

Non-destructive internal defects detection in apple fruits using novel x-ray dark field imaging and machine learning

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Objective: To propose a non-destructive and automatic method for apple internal defects detection based on novel x-ray dark field imaging and machine learning
Methods: In order to obtain healthy and defect fruits, 'Braeburn' apples were randomly divided and stored in optimal and browning-inducing conditions for 3.5 months. Intact apples were scanned using a grating-based interferometer to get conventional x-ray transmission images as well as novel dark field radiographs. The dark field image modality generates contrast images related to differences in x-ray scattering in the scanned fruit, while the transmission image render contrast due to differences in attenuation of the x-rays. For the data pre-processing, image type conversion and background removal were conducted to reduce computational cost and focus on the object in the image respectively. Then histogram-based and texture features were extracted globally through statistical methods. Those features were combined into latent variables by using the partial least square method. Optimal latent variables were selected through 10-fold cross validation based on the F1 score. Three different machine learning algorithms (linear discriminative analysis, linear support vector machine and logistic regression) were used to develop classifiers. 80% and 20% of the data were used to train and test these classifiers. Different metrics (accuracy, F1 score, recall and precision) were applied to evaluate classifier performance. As a benchmark, the same workflow was executed on the corresponding x-ray transmission images.
Results: From qualitive visual inspection, dark field images of defect fruits seemed to give higher contrast between healthy and defect regions compared with corresponding transmission images. For dark field image dataset, all three classifiers achieved 100% accuracy on the test data when optimal latent variables were used. Moreover, the linear support vector machine needed least number of latent variables. For the transmission image dataset, the highest accuracy was only 65% achieved by using linear discriminative analysis.
Conclusion:
The results indicate that the proposed method can non-destructively detect apple internal defects based on novel x-ray dark field imaging and machine learning.

Food future, innovation in teaching and learning, innovation and management

Oral

Combination of acoustic imaging and machine learning algorithms for the rapid characterization of jelly-based products

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Quality monitoring of jelly-based foods is an important issue to determine average compositional, textural, and/or rheological properties and sensory quality. In this sense, the development of non-destructive and low-cost systems for real-time prediction of the composition of these products plays an essential role in the industry. Further, the use of machine learning algorithms combined with real-time process information could contribute to achieving this goal. Thus, the main aim of this work was to assess the capability of using acoustical images obtained by ultrasound technology combined with machine learning algorithms for rapid and non-destructive prediction of jelly concentration on jelly-based products. For this purpose, jellies (bovine gelatin 1%, 5%, and 10% w/v) were prepared in silicon and polystyrene plates (diameter 9 cm, height 1.5 cm) in which ultrasonic measurements were conducted following a pre-established pattern (60 × 60 points separated by 1 mm). Images were built using three energy-related ultrasonic parameters computed in the time domain (peak to peak voltage, square norm, and integral). Principal component analysis (PCA) was calculated using the aforementioned ultrasonic parameters to extract uncorrelated latent variables which summarized 100% of experimental data variability. Subsequently, Support Vector Machines (SVM), Regression Trees (RT), Random Forest (RF), k-Nearest Neighbors (kNN), and Artificial Neural Networks (ANN) were used to describe the product concentration as a function of acoustics images projected in latent space and type of packaging material. Machine learning techniques were trained 100 times in a holdout approach, employing 75% of the experimental data set for training purposes and leave-one-out cross-validation, and the remaining 25% of the experimental data set was considered for the external validation process. Hyperparameters of each technique were optimized using multifactor analysis of variance (ANOVA) for minimizing the mean square error (MSE). The SVM model provided the highest goodness in the model validation (R2adj>99 and MRE<5%), suggesting that the methodology proposed in this work is of interest for the reliable, rapid, and accurate prediction of the concentration in jelly products packaged in different materials and its further in-line industrial application.

Oral

Mapping the variability to develop a decision for end quality of fresh horticultural product upon arrival in the retail by machine learning based techniques

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Food supply chains are confronted with increased consumer demands on food quality, safety and sustainability. On the other hand, one third of the globally produced food for human (more than 42% accounts for fruit and vegetables) gets lost or is waste every year. The current strategy to optimize postharvest supply chains is intensive in-transit time-temperature monitoring with quality evaluations when the shipments are transferred between stakeholders. That way, extensive amounts of hygrothermal sensor data and metadata (e.g. production area, variety, transit duration etc.) are gathered for each shipment. These data are however not used to their full potential to predict quality upon arrival at retail which is essential for several stakeholders since the quality evolution of the fresh horticultural produce is unique and differs between individual fruit due to pre-harvest biological variability between individual fruit at harvest and postharvest variations in hygrothermal conditions between refrigerated shipments. This drives our mission towards achieving higher fresh-produce quality with less variability, to reduce food losses and the associated environmental impact. Artificial intelligence techniques, such as machine learning (ML) models can be used as a valuable tool for aiding decision makers due to its ability to learn and find interesting patterns in data. However, the predictive accuracy of machine learning strongly depends on the quality and quantity of the respective training data and the choice of specific features. Here, our study aims to identify multiple correlations and derive the feature importance quantitatively on citrus shipment metadata and temperature sensor data to develop ML pipeline predicting fruit quality. For this, multiple ML algorithms are examined and their applications for the citrus supply chain processes are explored. To this end, we investigated supervised classifiers, logistic regression (LR) and random forest (RF), which are used to classify good or bad quality of products upon arrival at the market. LR classifier showed better classification accuracy with 69% than RF. Citrus end quality decision was mostly correlated with chilling injury defect (28%, the highest among other postharvest defects). Variability among product variety and production area have the largest effect on the model to predict good or bad arrival.

Food future, innovation in teaching and learning, innovation and management

Oral

Expert knowlege integration for smart tools modeling: application to wheat use

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The quality of wheat grain is generally determined with regard to its potential value for breadmaking through selected technological tests. With growing constraints affecting the production of wheat worldwide, it is critical to optimize the use value of wheat, in particular wheat produced locally. A proper evaluation of the wheat quality should associate a multifactorial characterization of the wheat with a specific use in the industry, e.g. for French bread, rye bread, biscuits and so on.

This work is part of the ANR Evagrain project, whose ambition is to design a decision support system (DSS) capable of computing an evaluation of the wheat use value from wheat grain characteristics. The evaluation takes the form of a prediction of the end-product properties. With this in mind, a database describing the characteristics of more than 100 wheat grains produced in France has been compiled by public and industrial laboratories of the cereal science field.
To annotate and structure the data with a standard vocabulary, we developed a wheat quality ontology through experts' interviews. Our ontology is based on @Web, a core ontology for the annotation of heterogeneous data sources.

More specifically, our ontology is structured so that to annotate each measurement of a specific wheat with the method (which device, protocol, etc.) and the sample information (origin, type, operator, variety etc.). This ontology will allow to feed automatically the DSS with upcoming data all along the project and beyond. It is also an essential medium to query and compare heterogeneous datasets by supplying all the necessary metadata.

Using this newly structured dataset, it becomes possible to learn complex models able to show the links between the different variables of interest. Moreover, by integrating expert knowledge, we aim to provide explanations for these links. To do so, we translate expert inputs as constraints used for guiding the learning of a Bayesian network (BN). As probabilistic graphical models, BNs are well suited to deal both with uncertainty (which is common in technological tests where measures can be imprecise and external factors have to be considered), and allow complex reasoning such as predictions and reverse-engineering.

Oral

A Q-learning approach to planning a sustainable food manufacturing system

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For the agri-food sector, the third most energy-intensive industrial sector, one of the major challenges is to reduce its carbon footprint and ensure sustainable manufacturing to limit its impact on climate change. In addition, recent global market instabilities with soaring energy prices have reinforced the need for the food sector to conduct an effective energy and transition policy. To meet this challenge, one of the alternatives is to replace carbon intensive processes with low-carbon processes involving electrical energy together with renewable energy as main sourcing energy for food processing. Such an evolution implies: (1) to consider the amount of the different sources of energy needed for a production plant and (2) to optimize energy costs by diversifying sources. Within this scope, this study aims at developing a novel scheduling approach integrating renewable energy use to meet demand over a limited planning horizon with the lowest possible costs for inventories, backorders, production setup and energy consumption. In particular, a food industrial scheduling problem is investigated with sequence-dependent that extends multi-products and multi-process capacitated lot sizing in a flexible flow line, in which non-identical machines works in parallel. An advanced mixed integer linear program adapted to renewable energy supply is proposed to provide an hourly production schedule, which minimizes energy and production costs. To bypass consuming execution time limitations and to realize the industry 4.0 vision for production optimization, an algorithm based on reinforcement learning is considered. This machine learning approach has gained in popularity in dynamic optimization problems since the last decade. Hence, it turns out to associate each machine of the process to an agent trained to minimize total cost function and to adopt cooperative multi-agent strategy to solve the global problem.
Numerical experiments are performed on a practical reference case. First, the efficiency of the proposed algorithm is evaluated against other advanced techniques such as metaheuristics. Then, the interest of the approach is discussed in terms of energy and financial improvements.

Food future, innovation in teaching and learning, innovation and management

Oral

A simple theory helps identifying which different rheological properties can result in the same syringe flow test performance of the International Dysphagia Diet Standardisation initiative (IDDSI)

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Texture modified food and beverages allows the care of patients with swallowing disorders. Ideally, the rheological behavior of such food products should be evaluated, to avoid aspiration and the risks of choking, while keeping as much as possible the pleasure to eat.
This study consider the syringe flow test, recommended by the International Dysphagia Diet Standardisation Initiative (IDDSI), for texture modified drinks, to better understand the relationship between rheology and the IDDSI's texture classification. We established a simple theory allowing to predict the IDDSI texture level from the beverage's rheology.

A rheometer with a Couette shear cell were used to characterize the shear rheology of Newtonian fluids with a range of shear viscosities from 0.04 to 1.31 [Pa.s], as well as different shear thinning solutions.
The theory was validated against the flow measured experimentally in different syringe geometries. Besides quantifying the final residue in the syringe, the analysis of the IDDSI test dynamics was completed using video recording, image analysis and a computer linked balance.

The simple theory presented in this study shows a good agreement with the experiments.
The theory is in turn used to identify, which different rheological properties can result in the same IDDSI syringe flow test performance. The boundaries between "IDDSI-similar" Newtonian liquids and shear thinning liquids with different flow indices are presented.

These results could be used to design drink flow properties to reach a desired IDDSI syringe flow test performance. They could also orient future clinical trials aiming at further verifying the relevance of the IDDSI syringe flow test with respect to in vivo flow during swallowing, or identifying potential areas of improvement.

Poster

A European FEEDtheMIND perspective for innovative numerical educational approaches in food eco-design development

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FEEDtheMIND is a 3-year ERASMUS+ project that started in 2019 and gathers 7 partners from 5 different countries (Austria, France, Greece, Slovenia and Spain). The objectives of this project are (i) to adapt, test and implement a digital educational platform focused on the development of an innovative food product; (ii) to facilitate the exchange of pedagogical methods between the different partner organizations in European higher education institutions; (iii) to contribute to rethinking curriculum design by enabling higher education institutions to offer online courses and hybrid practices. Our presentation focuses on the project's outputs and describes the digital platform with 4 learning modules that were developed. These modules concern the learning of knowledge in the following areas: creativity, business model, eco-design and project valorization. This platform offers students the possibility to develop their own knowledge acquisition according to their interests and to accompany the student teams during project-based learning approaches, such as the projects for the ECOTROPHELIA competition. The relevance of the platform was evaluated by the transnational team that was created during the project composed of 11 students from the partners universities. The team building happened online with the use of innovative approaches and collaborative tools. Eco-design of innovative food product “Refresh” was done in hybrid mode with the transnational team meeting both online and physically in the laboratories of Polytechnic University of Valencia (Spain). The exchange of coaching practices among higher education institutions was beneficial for the transnational team that was able to work from their different countries and meet at specific milestones to work on the product's development and finalization. This project led to the successful participation of the transnational team in both ECOTROPHELIA Greece competition in June 2022 and in ECOTROPHELIA Europe competition in France in October 2022. This 3 years' experience that occurred during the Covid sanitary crisis emphasized on the need to develop more online and hybrid educational approaches and tools while proving that this combination can add to the students' and instructors' experiences. The European transnational team was successful on both human and educational levels and opens the path for new perspectives and mindsets.

Food future, innovation in teaching and learning, innovation and management

Poster

Continuous infrared popping: Effect on key physicochemical attributes of popcorn

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The effect of continuous infrared (Co-IR) popping at different power (600, 700 and, 800 watts (W) Co-IR power) and constant distance from sample (5 cm) on the key physicochemical properties of popcorn (Zea Mays L. var. Everta) (popping properties, energy consumption, morphology (SEM), sensory properties, and color) was investigated. According to the popping properties results, optimum treatment for Co-IR popping of popcorn was 700 W Co-IR power. Color were significantly changed ($P < 0.05$) during Co-IR popping. L*, a*, b*, ΔE, hue, and chroma values of Co-IR popped popcorn (700 W Co-IR power) were 71.40, -2.73, 15.44, 33.13±1.92, -1.40±0.29, and 15.68±1.07, respectively. The minimal energy usage was attained at 0.013 kWh at 800 W Co-IR power. In SEM analysis, with increasing the IR lamp power, the cavities size was increased (the cavities number per unit area decreased). The largest increase in the popcorn cavities size was determined at 800W Co-IR power. The highest consumer acceptance of Co-IR popped corns was obtained 700 W Co-IR power. This is the first study on Co-IR expansion technology for popcorn popping, and the findings show that the IR expansion method is very efficient in the popcorn popping process.

Food future, innovation in teaching and learning, innovation and management

Poster

FOOD DESIGN THINKING APPLIED TO THE CONCEPTION OF PROTEIN AND VITAMIN-RICH PRODUCT FOR SENIOR CONSUMERS

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Design Thinking (DT) is a tool used for product development, focused on the relevance of solutions from the point of view of the customer (user), based on empathy, co-creation and experimentation, aiming to generate creative and prototype ideas. User prioritization distinguishes DT from conventional product development models. However, employing such an empathic vision to understand how population aging influences the development of a food is still not a reality. This study aimed to develop a food with high protein and vitamin content, aimed at senior consumers, applying DT fundamentals. The work was divided into stages - empathy, analysis, ideation, prototyping, delivery. In the initial results, 127 answers were obtained from the scanning survey questionnaire, with an exploratory screening character to select the target audience. Non-inclusion criteria were applied, generating a final sample of ten participants for an in-depth, virtual interview with a deep analysis character. A team of designers was formed, who realized the great challenge of practicing otherness, listening empathically, without interfering and/or directing the user's responses. In the empathy phase, it was deeply understood how senior consumers relate to food, brands, through experiences, sensations, pain, needs and two extreme profiles were identified. In the analysis phase, an affinity diagram was set up mapping collected insights, the pandemic (Covid-19) was observed influencing the food life of vulnerable people, even those of higher economic class. A deep investigation questionnaire was applied to ascertain about food consumption and level of understanding of the elderly about proteins. The persona, the challenge and the critical point of the project were identified: to develop a food rich in vitamins and proteins, which connects health and pleasure, softness and crispness and does not "denounce" the consumer's age.

Food future, innovation in teaching and learning, innovation and management

Poster

'Ultra processed', as defined by NOVA, is a misleading term – Insights from an in-depth comparative investigation of processing intensity on Scandinavian dairy products

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Objective
A high intake of foods classified as 'ultra processed' on the NOVA scale have detrimental health effects according to several studies. Consequently, national food authorities have decided to advice against consuming 'processed' or 'ultra-processed' foods.
The term 'ultra processed' implies that these are foods that have undergone intensive processing. However, a closer look at the NOVA scale, shows that it is a complex measure trying to combine a wide range of factors such as palatability, number of ingredients and marketing strategy of the producer, as well as processing intensity. Previous studies have pointed to that this makes NOVA difficult to fully understand and apply, even to experts within the food and health sector. The objective of this study is to investigate to what extent NOVA-classification correlates to processing degree in a more objectively defined sense (using the dairy category as an example).

Methods
Two measures of objective extent of processing are chosen, thermal effect (chemical effect, C*) and extent of shear (integrated over time), and quantified for a selection of the most commonly consumed dairy products in a Swedish setting (low-pasteurized milk, ultra-high temperature treated milk, plain and fruit yoghurt, ice cream, whipped cream), based on typically used processing lines, and established relationships for shear rate in processing equipment. As a comparison, a nutrient rich food index (NRF9.3) is also applied for each food.

Results
The products differ in terms of how intensively they have been processed (using the objective definition). However, no correlation is found between NOVA classification and objectively measure extent of processing–e.g., plain yoghurt (NOVA group 1, 'minimally processed') and sweetened fruit yoghurt (NOVA group 4, 'ultra processed') are indistinguishable in terms of applied thermal effect and shear. However, the NOVA-classification does systematically classify the dairy products with a low nutrient-rich index as 'ultra processed' (regardless of how intensively processed they are).

Conclusions
A high score on the NOVA classification does not correspond to being more intensively processed for the dairy segment, suggesting that referring to NOVA group 4 foods as 'ultra processed' might be misleading.

Food future, innovation in teaching and learning, innovation and management

Poster

Characterization of original and solvent-treated cricket (Gryllus bimaculatus) powder for future food

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Edible insects are a new option of protein, fat, and minerals source, and are gaining attention all around the world. The use of insects has ecological and economic advantages when compared to other farming options, like the reduction of greenhouse gases emission and the reduction of water waste. The objective of this study is to evaluate the difference in nutrients, bioactive compounds, and powder properties after different treatments.

The treatment of cricket powder was performed using four different solvents: Milli Q water at pH5, ethanol 20%, ethanol 99.5%, and hexane. The powder was washed with the solvents individually for 2 h under stirring. After that the solution was centrifuged, the powder pre-dried overnight in the fume hood, and freeze-dried posteriorly. Proximate analyzes were determined through moisture, chitin, protein, ashes, and fat content. Osborne's classification of the proteins was analyzed using protein solubility. Phenolic content and antinutritional compounds were analyzed using Folin Ciocalteu method.

Significant differences were observed in the proximate analyzes after the solvent treatments, with a reduction of fat content from 33% in the original powder to 7% in the powder treated with ethanol 99.5%. At the same time, the amount of protein in the treated powders increased from 55.4% (in original powder) to 72% (ethanol 99.5% treated powder), which influence the nutritional value of the final product. The removal of fat also contributes to changes in the color of the powder, making it clearer. When analyzed, the antinutrients show a significant decrease in the powders treated with aqueous solvents. Due to the removal of fat, other compounds present in the powder tend to be more concentrated, this can be observed in the phenolic compounds present in the powder: after the treatment with ethanol 99.5% of this value has increased.

In conclusion, cricket powder is a good source of protein, fat, and phenolic compounds. The treatments applied improved the nutritional profile of the powder, increasing the protein content, reducing the fat, and increasing the phenolic compounds.

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Food future, innovation in teaching and learning, innovation and management

Poster

The green gap in the food future of teenagers, the case of insects' consumption.

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Industrial food production contributes to resource depletion and pollution (Vermeulen et al. 2012). Thus, eating less meat is considered as a sustainable behavior change (Loy et al., 2016). One of the pathways to food transition is the consumption of insects (Gallen et al., 2019). In this context, promoting responsible consumption among young people is a priority (Fischer et al., 2017). This requires understanding what motivates and hinders adolescents to change their behavior (Bruni et al., 2012).
Research in sustainable behaviors shows that there is a so called “green gap” between pro-environmental attitudes and real consumers' behaviors (ElHaffar et al., 2020). Three types of benefits to the adoption of sustainable practices have been identified (Dekhili et al., 2021): self-centered benefits (they are concrete and constitute the dominant motivation); altruistic benefits (caring for others); biospheric benefits for animal welfare and the environment (considered abstract and unpredictable). Thus, cognitive myopia prevents consumers from considering the future benefits of their consumption because of the immediate costs or sacrifices it generates and promotes the tendency to favor alternatives whose effects are concrete and immediate (egocentric benefits) (Trudel , 2019).

Objectives: This research aims to study the obstacles and motivations of adolescents to consume insects in order to identify a possible "green gap".

Method: Qualitative study with 31 adolescents (15 girls and 16 boys) aged from 12 to 18 y.o., exposed to visuals of insects.

Results: Concerning the reduction of meat consumption, the respondants' motivations are linked to the biospheric benefits with the protection of animals above all, then of the environment, while the obstacles are linked to the renunciation of egocentric benefits (pleasure, protein intake). The benefits of insects' consumption are first egocentric and above all linked to social valuation, then biospheric, and to a lesser extent altruistic. The obstacles are related to disgust related to insects.

Conclusion: In order to promote this food of the future among teenagers, it is possible to reduce the green gap by highlighting the egocentric benefits they seek, namely the experience of social valuation among their peers, but also the biospheric benefits associated with animal welfare.

Poster

From experimentation to modeling via an iterative and collaborative teaching approach in food and bioprocess engineering

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The objective of this project developed in AgroParisTech is to implement an innovative pedagogical method whose aim is to clarify the **continuum between experimentation, data acquisition, modeling and simulation**. We wish to apply this methodology to the design of heat exchangers at different scales. Through this project, we would like to effectively weave links between experimentation at the laboratory and pilot scales, data acquisition, modeling and simulation.

To do this, we propose to set up a demonstrator based on the case of a well-known unit operation (heat exchangers). The steps of the method will be : (1) small-scale experimentation with real data acquisition; (2) numerical treatment of these data and comparison with a theoretical model; (3) enrichment of the model with the experimental data acquired; (4) simulation of the operation on a larger scale with use of correlations between adimensional numbers and (5) comparison with measurements obtained on a larger equipment already available in our pilot-plant laboratory.

The first point will be carried out in the form of practical work sessions using micro-pilot heat exchangers proposed by G.U.N.T company (Barsbüttel, Germany) specialised in the development of equipment for engineering education. The equipment acquired will therefore consist of various small heat exchanger modules (coaxial, multitubular and plate) connected to a data acquisition system and a supply unit of hot and cold fluids. The small size and the flexibility of use of these devices should hence allow students to obtain in a short time of experimentation a consequent experimental data base.

The other parts concerning data processing, modelling and simulation will be carried out in the form of tutorial sessions with the objective of developing digital notebooks in Jupyter ecosystem using Python as programming language.

The main impact of the project is the alignment of our pedagogical method with the reality of practices observed in the industrial and research worlds in process engineering applied to food and bioproducts. It seems obvious that the experimental and theoretical tools developed during the project can be applied in a second phase to the case of other unit operations.

Poster

NIR-hyperspectral imaging and multivariate analysis for cinnamon authentication

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Cinnamon (*Cinnamomum spp.*) is one of the most used spices in the pharmaceutical and food industry due to its medicinal and aromatic properties, where *Cinnamomum verum* (true cinnamon) and *Cinnamomum cassia* (false cinnamon) are among the main different species of the genus *Cinnamomum spp*. Food fraud is a recurrent practice in the industry, in which a food is intentionally modified by substitution, manipulation, addition or falsification. The herbs and spices industry is one of the most vulnerable sectors due to its high economic value. *C. verum* is commonly adulterated with *C. cassia* due to its greater industrial presence for economic purposes. The botanical origin of cinnamon is commonly established through sophisticated analytical techniques such as high-performance liquid chromatography (HPLC), DNA, gas chromatography coupled to a mass spectrometer (GC-MS), nuclear magnetic resonance (NMR), and DART-QToF. -MS in real time. While these methods are efficient and accurate, they are typically time-consuming, reactive, and expensive. This work aimed to develop classification models based on NIR-hyperspectral imaging (NIR-HSI), for authentication of *C. verum* and *C. cassia* sticks (105 samples) from India, Peru and Brazil. The NIR-HSI images were acquired in the spectral range of 953–1710 nm with 5 nm intervals, totaling 159 bands. Initially, principal component analysis (PCA) was applied to reduce dimensionality and explore NIR-HSI data. The scores showed high similarity between the species due to similar concentrations of macronutrients. PC3 allowed better differentiation among classes in relation to PC1 and PC2, with peaks related to phenolic/aromatic compounds, such as coumarin (*C. cassia*) or catechin (*C. verum*). Partial least squares discriminant analysis (PLS-DA) correctly classified more than 90% of the samples according to species, with error = 3.3% and accuracy = 96.7%. A permutation test was applied to validate the reliability of the classification model, indicating that the PLS-DA model presents reliable predictions that are not the result by chance. We demonstrate that the combination of NIR-HSI with chemometric tools provides a reliable, fast and non-invasive analytical system for authenticating cinnamon sticks based on classification of *C. verum* and *C. cassia* species, a promising alternative to conventional destructive methods.

Poster

Analysis of the sustainability of an aquaponic farm through a life cycle analysis

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Introduction: “Abbaye farm” is commercial aquaponics exploitation located in Chaumousey, France, created in 2019. The farm's management includes a high diversity of vegetables (more than 30 species throughout the year), seasonal production, no heating of air or water, no artificial lighting, and the rearing of non-carnivorous fish species. The primary aims of this work are (i) identifying the “hot-spots” of the environmental impact of commercial-scale aquaponics systems by using the normalized LCA method; (ii) comparing the results to other LCA publications; (iii) proposing effective strategies to reduce the overall impact of the “Abbaye farm”. Method: A method-based Life Cycle Assessment (LCA) analysis was used to assess the environmental impact of “Abbaye farm”. SimaPro software was used for LCA as the modelling platform and data for the life cycle inventory were modelled for each sub-system production using this software. A comprehensive cradle-to-gate LCA using multiple midpoint environmental impact categories (such as global warming (GW), land use (LU), water dependency (WD), freshwater/marine ecotoxicity (EC) and eutrophication (EU)) was analyzed in this case study of a commercial aquaponic system. Some authors have used the LCA tool to investigate the environmental sustainability of aquaponics, and it is typically utilized on small-scale systems, research pilots, or even modelled aquaponics Results: The main contributors to the aquaponic system’s environmental impact hotspots were identified: equipment, fish feed, and electricity contributed to more than 90% of environmental impacts in all investigated categories. These values were then compared with other LCA literature studies on aquaponics, hydroponics, and aquaculture. The comparison with other aquaponics and alternative systems showed that Abbaye farm is more sustainable regarding environmental impacts. Finally, effective strategies were proposed for leading to better system management and supporting the long-term decisions on the environmental sustainability of aquaponics as a promising agri-food production system.

Poster

Raman spectroscopy in the evaluation of different oleogels types

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Oleogel is a promising alternative that can be incorporated into different health food as a conventional fat replacement. The oil type is a key factor when determining technological properties and choosing applications since they are exclusive in their fatty acid composition, atomic weight, and thermal characteristics, which influences the gelation capacity. Therefore, this work aimed to analyze and classify these oleogels in a fast reliable way (free of chemicals) using Raman spectroscopy. Raman spectroscopy is a rapid detection technique and provide a structural fingerprint. It can be used to characterize and identify cis and trans isomers, as well as analyze the structure and classification of oils. Three oleogels were prepared with 95% of oil (sunflower, soy, olive), and 5% of bee wax as structuring agent, melted at 90 °C. Official methods were used to access the fatty acid composition of peroxides and free fatty acids. Rheology analyzes were also conducted to aid in classification. A total of 240 spectra were acquired 0.5 cm from the sample. The spectra were collected in a range of 785 - 1065 nm and the laser power was 300mW. After spectra pretreatment, PCA was performed and it was possible to observe the sample clustering for each oil type in the PC scores. Classification models were then performed using the full dataset with samples split in calibration set 70% (162 samples) and validation 30% (78 samples). The best SIMCA model classified with 98% of accuracy; some samples of olive oil were misclassified to sunflower oil. PLS-DA reached better performance than SIMCA, classifying samples with 100% of accuracy, demonstrating that a portable Raman spectrometer in tandem with chemometrics can be a promising tool to classify different types of oleogels.

Food future, innovation in teaching and learning, innovation and management

Poster

Low-cost e-nose as an affordable tool for identification of black tea origin

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Tea adulteration is a common practice where the leaves of high quality are mixed with samples from cheaper manufacturers. Identification of black tea origin is, therefore, extremely important to guarantee product quality. Multi-sensor devices such as electronic-nose (e-nose) is a fast and non-invasive method and stands out as a better alternative to laborious and expensive methods such as gas chromatography-mass spectroscopy (GC-MS) and high-pressure liquid chromatography (HPLC) for identification of tea origin. This work aimed to use a low-cost (less than $200) e-nose as a non-destructive tool to classify tea leaves from two different countries (Brazil and India). The e-nose system was equipped with 8 gas metal oxide sensors (MOS) for analysis of six samples from Brazil and three from India. Principal Component Analysis (PCA) was used to investigate the variations in the data obtained by e-nose. Scores plot PC1 vs PC2 explained 99.21% of the total variance and showed a complete separation between the two groups of samples. Partial Least Squares-Discriminant Analysis (PLS-DA) was applied to classify the leaves into their respective classes, achieving sensitivity of 100%, while accuracy was close to 80% when discriminating between Brazilian and Indian samples. Therefore, the low-cost e-nose was able to classify the two classes of tea with reasonable accuracy and can then be used as an affordable way identification of black tea origin.

Poster

Identification of adulteration in butter cheese using NIR spectroscopy

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Artisanal cheeses are appreciated around the world for their distinctive sensory characteristics compared to other cheeses, which reflect the characteristics of the producing region and traditional production methods. Traditional Brazilian cheeses have received greater appreciation in recent years, which makes it necessary to develop authentication methods to establish identity and differentiate them from products with false statements on the label or adulterated by the substitution of authentic material. The objective of the present study was to develop a method based on NIR spectra acquired in a portable equipment, as a non-destructive, fast and relatively low-cost alternative to identify adulteration by soybean oil in butteroil cheese, a typical Brazilian cheese. Authentic butteroil cheeses and cheeses intentionally adulterated with soybean oil (5 to 100%) were prepared, and 12 commercial samples were acquired, which were identified as authentic and adulterated after identification of fatty acid profile. Principal component analysis (PCA) showed a clear separation between pure and adulterated samples in the second principal component (PC2), which is suggested to be related to the proportion of polyunsaturated fatty acids present in the cheese, since the increase in adulteration with soybean oil shifted the samples to the positive part of PC2. The main bands that contributed to the clustering of the samples, 1170 and 1210 nm, are attributed to CH bonds (-CH2 and HC=CH) present in aliphatic fat chains. The PLS-DA classification model (1) developed with 70% of the samples (randomly distributed set) correctly classified 94.98% of the remaining samples (30%), while the PLS-DA model (2) calibrated only with the samples developed in the laboratory correctly classified 88.80% of the samples from the independent set (commercial samples). These results demonstrate that efficiency portable, low-cost NIR spectrometer can be a valuable tool to assess butteroil cheese authenticity.

Food future, innovation in teaching and learning, innovation and management

Poster

Rapid estimation of protein and lipid content in Black Fly Soldier (Hermetia illucens) larvae flour using a portable NIR sensor and chemometrics

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The rapid growth in population requires that we seek new sustainable sources of food. Insects are shown as a promising source of protein and lipids, currently being used in the production of animal feed and biodiesel. The black fly soldier (*Hermetia illucens*) (BFS) larvae have shown a great capacity to transform organic waste into quality protein and lipids, meeting the requirements of the circular economy. In this work, we propose to use a low-cost portable NIR sensor to estimate protein and lipid content in BFS larvae flour. Robust prediction models were trained and validated using powerful chemometrics tools such as Partial Least Square Regression (PLSR) and Support Vector Machine Regression (SVMR). Variable selection using interval PLS (iPLS) was used to simplify the models and improve performance. The results show that the regression models allow a reliable estimation of the lipid and protein content with a correlation coefficient (R square) > 0.7, ratio prediction deviation (RPD) > 2.5 and RMSEP < 3%. Finally, it is possible to conclude that regression models based on the portable NIR sensor can help a fast, chemical-free, non-destructive and reliable estimation of protein and lipid content in BFS larvae flour. This would allow better quality control in the nascent insect industry in Brazil, allowing it to move towards the well-known industry 4.0.

Food future, innovation in teaching and learning, innovation and management

Poster

Development of Immunosensor for Rapid Detection of Bacillus Cereus in Food

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Objective: Food borne pathogens are the major cause of the outbreaks in which, bacteria dominates more in cause of it. B. cereus outbreak is one of the predominant among the major pathogenic bacteria, which is rarely reported. It causes two types of diseases that are emetic and diarrheal syndromes. Largely, B. cereus outbreaks are reported from the cereal and dairy-based food products due to the highest cereulide production from their composition such as vitamins and trace elements. Compared to other pathogenic bacteria, there is lack of proper rapid monitoring system for B. cereus in food. The electrochemical immunosensor is one of the most promising detection approaches for pathogenic microorganism in modern technologies. The study was aimed on the development of portable immunosensor for rapid detection of B. cereus using square wave voltammetry.

Methods: Anti-Bacillus cereus polyclonal antibodies were immobilized through a cross-linking method on a chitosan/gelatin-modified electrode. Antibody immobilization on the electrode surface was investigated using scanning electron microscopy, Fourier transform infrared spectroscopy, contact angle, and cyclic voltammetric techniques. Bacillus cereus was detected using square wave voltammetry under optimal conditions, based on a current change that occurred during the specific interaction between antibody and Bacillus cereus. The performance of fabricated sensor was evaluated.

Results and Discussion: The fabricated immunosensor exhibited a LOD of 101 CFU/mL, LOQ of 103 CFU/mL, detection time < 50 min, linearity ranged from 101 to 108 CFU/mL, high specificity, good reproducibility and regeneration efficiency. With a recovery of 85–107%, it confirmed accurate identification of B. cereus in a complex matrix sample such as infant food and rice-based products. The immunosensor was found to be stable for 3 weeks with 70% relative activity. Therefore, the fabricated immunosensor has been shown to be a potential tool for food quality and safety control. Further studies could be elaborated in the improvement of sensor by introduction of a conducting polymer and the detection of B. cereus spores in real time analysis.

Food future, innovation in teaching and learning, innovation and management

Poster

Fostering food industry sustainability: how data management and digital solutions can help. Study-case of concentrated orange juice production

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Cyber-physical systems and internet-oriented technologies are the basis of the new sustainability-oriented Agrifood 4.0 industry which calls for more big data to be collected and analysed. For food processing units too, proper handling of product and process data has, therefore, the crucial role in building reliable digital replicas of the real system, digital twins, to be used for simulation and consequent sustainable optimization actions.
The often-overlooked prerequisite to digitalization is to verify the reliability of measured data which must be corrected in order to guarantee the perfect closure of the system balances.
As an example, the industrial food process of concentrated orange juice production was analysed. In particular, the research shows in details the first step of the digitalization approach: data reconciliation, a technique that uses material and conservation equations to minimize the actual measurement error in-process data. Indeed, data reconciliation means applying a quantitative mathematical procedure to measured material and energy flows along the process in order to estimate their accuracy and, eventually, correct them.
Data reconciliation was implemented in GNU Octave v6.0. Industrial observations regarding material fluxes were adjusted into reconciled values and the percentage error was calculated over each flow.
The energetic data assessment was also performed using the Aspen HYSYS v10.0 software which allowed evaluating latent heat exchanges and the amount of energy expenditure or intake by steam and juice, respectively. Unitary operations namely first thermal treatment, concentration and second thermal treatment, were mathematically modelled, and, in particular, the energy balance was set.
Ongoing research applies the present outputs to create the digital twin on which simulating material and energy flows to identify the best process optimization strategy, i.e. to act for the sustainable improvement of the studied food process.

Poster

Study of the physicochemical and functional properties of Tenebrio molitor larvae defatted flour and evaluation of its application in hamburger

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According to a study published by the Food and Agriculture Organization FAO in 2021, the global population will reach approximately 9 billion by 2050. With the fast growth of the world's population, new viable food sources such as edible insects are being explored. This research aimed to obtain Tenebrio molitor defatted flour (TDF), investigate its nutritional values and functional properties and analyze the characteristics of a hamburger added with 4% of TDF. The functional properties evaluated were emulsion capacity (EC), emulsion stability (ES), foaming capacity (FC), water absorption capacity (WAC), and fat absorption capacity (FAC). Instrumental color (L*, a*, b*), cooking yield, shrinkage, and diameter reduction analysis were carried out to evaluate the physical properties of the hamburgers. Also, the hardness, springiness, cohesiveness, gumminess, chewiness, and resilience values were determined by texture profile analysis (TPA). The defatted flour chemical composition (g/100 g, wb) consisted of (12.2±0.9) % moisture, (60.5±7.5) % protein, (7.9±1.8) % fat, (4.0±0.1) % ash, and 15.43 % of carbohydrates. The results of the functional properties showed EC = (57.33±0.28) mL/g, ES = (76.67±2.89) %, WAC = (1.35±0.19) mL/g, FAC = (3.63±0.01) g/g and FC = (52.88±4.08) %. The raw hamburgers supplemented with insect flour indicated similarities in the L* parameter ($P>0.05$) with the control, while the parameters a* and b* differed significantly ($P<0.05$). However, after the cooking process, there were no significant differences ($P>0.05$) between each color parameter. The TPA results showed no significant differences between hamburgers ($P>0.05$) for all the textural properties. The supplemented hamburger presented a better outcome regarding its shrinkage and diameter reduction ($P<0.05$) than the control. However, there was no significant difference between cooking yield results ($P>0.05$). The hamburger control showed cooking yield (64.8±3.5) %, shrinkage (21.7±3.7) %, and diameter reduction (21.0±2.7) %, while the supplemented hamburger showed (75.9±0.4) %, (10.4±1.2) % and (10.5±1.3) % for the same parameters, respectively. The defatted insect flour proved a potential protein source, improving some beef hamburger properties, such as less shrinkage and diameter reduction, while maintaining its traditional texture profile and color after cooking.

Poster

Designing 3D printable food based on unexploited seafood: printability assessment

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Fish discards are a worldwide phenomenon resulting from fisheries and have been the subject of great concern on the part of all players in the sector, whether they are government, fishermen or scientists. Numerous species of low or no commercial value are discarded every year and most of them have a high nutritional value. However, due to economic reasons and/or consumer acceptance, they do not reach our food chain. In recent years, numerous studies on three-dimensional food printing (3DFP) have demonstrated the value of this technology. However, adapting the existing 3D-printing technology to the food sector has generated new challenges, as food materials often consist of many different components with distinct properties. Traditionally, food materials such as fish, present unsuitable properties for printing, requiring the addition of hydrocolloids and other viscosity-modifying materials to induce the appropriate properties to the formulations. The aim of this work was to design and development printable seafood-based formulations. Unexploited fish species and by-products from the seafood industry, attractive at multiple scales with excellent sensory and nutritional properties, were selected, contributing to the transformation of seafood "waste" back into perfectly edible foods. Food inks were prepared by adding different hydrocolloids and other viscosity-modifying agents. The characterization of the fish-based formulations and the optimization of the printing process were done to yield the best printing products. First, the raw fish-based inks were subjected to dynamic oscillatory analysis to characterize its viscoelastic behavior with the best formulations being chosen for the optimization of the printing process. Second, the parameters of printing speed and flow level were optimized resulting in the best printed structures. Preliminary results showed that the addition of corn starch and carrageenan increase the consistency index in the fish formulations and improve the printability using extrusion-based 3D-printing. This work contributed to the development of innovative, healthy, and sustainable food products and to reshaping food waste into new highly valuable ingredients employable to create nutritious and attractive edible food.

Food future, innovation in teaching and learning, innovation and management

Poster

CHALLENGES OF CAMEROON AGRICULTURE

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Abstract

In our present Century, Food and Agricultural stakes are sinuously rushing in a difficult legible heading. Crossing a transitory phase period between Agriculture, Traditional, Urban and Modern, the affirmation of a conquering alimentary identity and Nationalist openings is confuse with an Extraordinary Demographic Period of human scale history. Millions of people are worried about the innovation of urban agriculture for food and health security. Food education at the confines of the world's greatest stakes proves necessary, since the order oneself retreat combines with the passion of solidarity and social progress, advance in technology, facilitating our life at same time generating new threats for citizenship. In this Article, we propose another way of reading the heterogeneous world of yesterday, today and tomorrow. Not only for Historians but also by associating Scientific Relations of Social and Human Researchers. Such a step is necessary to endorse the word of reading, for comparism and review of an agriculture in full mutation. It also instigates by referring to History, Social force, Economic stakes and Diplomatic globalization food teste, intention and invention, which change with the everyday society. You will find out that analysis done in this article are sometime completely done events through original texts, assembled around the five fundamental notions: International Relations and Geopolitical Agriculture of yesterday; Yesterday Urban Economic Agriculture; Environmental and Food Climate Stakes, Science and Culture adapted to agriculture and food mutations.

Keywords

Yesterday Urban Agriculture, Food Stakes, Geopolitics of Agriculture, Contemporary World

Poster

European Qualifications and Competences for the Vegan Food Industry

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The Erasmus+ EQVEGAN project (eqvegan.eu), coordinated by the Polytechnic Institute of Coimbra (Portugal), started in December 2020.
The objective of the project is to support the transformation of the plant products processing sub-sector (vegetables, fruits, cereals, legumes and oilseeds), by responding to the urgent needs for upgrading staff skills and mobility of professionals in Europe. EQVEGAN thus aims to improve the skills of professionals in the plant-based food industry, particularly in their mastery of new processes and technologies.
This project therefore contributes to increasing the proportion of plant-based foods in consumers' meals and is part of the trend of consumers turning to more sustainable and healthier diets.
Four training modules have been developed in the EQVEGAN project, namely:
- Processing of plant-based products
- Green skills
- Soft skills
- Digital skills: digitization and automation

The participants will have the possibility to register for free to these training modules.

Special Session Fouling & cleaning

Oral

A microscopic look at the fouling mechanisms in dairy protein mixes by rheometry and microfluidics

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Thermal fouling is an unsolved and costly question for the dairy industry and consists in the accumulation of the solid fraction of a processed liquid stream on a stainless-steel surface due to the combined action of flow and thermal/concentration gradients. Understanding and preventing the phenomena related to thermal fouling is of paramount help to optimize the operation unit efficiency and to improve the quality of the products. Until now, most of the studies available in the literature focused on the fouling dynamics in heat exchangers and led to contradictory results based on the off-line analysis of the solid deposits. Conversely, the fouling mechanisms have been rarely explored in the evaporators despite their increasingly essential and sensitive use in dairy industry (*e.g.*, infant formula production). The hypothesis explored in this work is that the initiation of the fouling process is not exclusively due to protein thermal denaturation in the liquid stream once a critical temperature is achieved (T>65°C), but also to the impact of the shear rate near the equipment walls. Mixes of whey proteins and calcium with different overall concentrations were processed by rheometry, undergoing the range of temperatures (45-80°C) and shear rates ($100s^{-1}$) typical of falling film evaporators in a wide temporal range (0-4h). The effect of the combined thermal and shearing action on protein denaturation/aggregation was evaluated:

- In the bulk, by extracting the kinetics of denaturation in the solutions using high-performance liquid chromatography (HPLC) and estimating the average aggregate size using dynamic light scattering (DLS);
- At the solid-liquid interface, by observing the formation and the development of the deposits (density, size, shape) at different local shear conditions using an optical microscopy.

The results provided an insight into the dependency of fouling mechanisms on key factors such as time, shear and concentration. Starting from this rheometry-based approach, the challenging next step was to provide a direct observation of the fouling dynamics in dairy mixes by microfluidics. Preliminary tests were conducted in microchannels with variable geometries reproducing the environmental and flow characteristics typical of the evaporators with the aim of characterizing the different steps of the deposit accumulation.

Special Session Fouling & cleaning

Oral

Role of calcium and casein micelle on the thermal denaturation of whey protein solutions and fouling mechanisms

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Fouling of heat exchangersin the dairy industry during pasteurization or UHT treatments is a persistent issue which is not yet totally understood and consequently is still a challenge to overcome.
Many previous works demonstrated the key role of protein in the initiation of fouling and mentioned that the denaturation of β-lactoglobulin (β-LG) is key factor responsible of the fouling build up.
However, less studies in the literature addressed comprehensively the influence of mineral or casein-micelle and its consequence on the amount of fouling. The objective of this work is to contribute to this field.
For that, fouling experiments (at the pilot scale) and kinetics parameters of denaturation obtained with reconstituted solutions at different calcium/protein molar ratio and at different casein/protein molar ratio were analysed and discussed.
Results established that both the β-LG denaturation rate constants and the distribution of fouling in the PHE were strongly impacted by the calcium/protein molar ratio for casein free solutions and that presence of casein radically changes fouling rate. It was concluded that casein micelle acts as a natural calcium chelator during thermal processing and therefore mitigates whey protein fouling. Moreover more dissociated caseins into the serum phase might be sufficient to perform chaperone-like functions.
For the conditions investigated, results established that the total deposit mass increased with the increase of the calcium/protein molar ratio. This investigation clearly shows that limiting protein concentration is not necessary a pertinent pathway to decrease fouling mass. However, it suggests that controlling the mineral balance is a key lever.

Special Session Fouling & cleaning

Oral

Minimising energy use in milk heat treatment using a dynamic fouling predictive model

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Objective: Today, energy consumption reduction in food manufacturing is at the centre of scientific and industrial interest. The aim of this study is to identify processing conditions to reduce the energy consumption in conventional milk processing and cleaning-in-place, using a dynamic fouling predictive model. During the thermal treatment of milk, a fouling layer develops on the inner surface of the plate heat exchanger, which acts as a thermal insulator. As a result, heating energy needs to be supplied at an increasing rate to ensure sufficient pasteurisation. Additionally, the frequent application of the cleaning-in-place process to remove fouling demands considerable energy for heating the cleaning fluids.

Methods: A model that predicts the impact of fouling on energy use during milk processing and cleaning was developed following a mechanistic modelling approach. Literature kinetic models were used to predict fouling dynamics during milk processing and cleaning. To achieve realistic results for fouling prediction, a data-driven regression model for a key parameter of the fouling kinetic model was developed. This was accomplished using logged temperature and flowrate data from a pilot scale milk heat treatment processing line in which trials were performed under a range of processing conditions. The impact of fouling on energy use was evaluated by applying first principles of heat exchange.

Results: The model was able to predict the fouling layer growth and depletion during processing and cleaning respectively. The model was simulated under a range of effective processing and cleaning-in-place operating conditions to identify conditions that can minimise energy use. The results were visualised through energy heatmaps. Results demonstrated that a 50C decrease in heating and cleaning medium temperature and a 10-minute reduction in cleaning time can save up to 24% of the energy use for milk treatment.

Conclusion: Simulations showed processing and cleaning-in-place operating conditions that can best reduce energy use whilst still ensuring sufficient processing and cleaning. Minimising energy use in conventional milk processing can lead to substantial savings in dairy manufacturing. In addition, this model can contribute to reducing the carbon footprint of milk which is a highly consumed product that has a significant global environmental impact.

Oral

Investigation of Blended Milk-Pea Protein Beverage Fouling using Quartz Crystal Microbalance with Dissipation (QCM-D)

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The fouling of beverages containing plant-based proteins seems to be unique when compared to more traditional protein beverages. The influence of thermal treatment on fouling and foulant removal of milk/pea protein blends has been investigated. Fouling of several blends have been evaluated at two temperature ranges: 65°C, 75°C and 85°C and UHT temperatures of 112°C, 122°C and 132°C using a quartz crystal microbalance with dissipation (QCM-D). Removal of the foulant was evaluated using a water rinse, a cleaning solution followed by a final water rinse. The foulant deposition and removal were evaluated at a defined flow rate over the QCM-D sensor with four 15 min phases, including creation of the foulant, removal by an initial water rinse, removal by a 0.1M NaOH cleaning solution and a final water rinse. The shift in frequency (ΔF) and dissipation (ΔD) from the QCM-D sensor were measured during each phase of the experiment.

The frequency shift (ΔF) values were converted to mass density (mg/m^2) adsorbed on the sensor surface using the Sauerbrey model and the fouling rate was expressed as mass density per unit time (mg/m^{2}min). It was observed that blended beverage has a lower fouling rate as compared to skim milk having the same protein content and the fouling rate decreases at all temperatures on addition of pea proteins. The removal of foulant using an initial water rinse was not influenced by temperature and foulant removal of blended beverage is easier as compared to skim milk. Only 25 % of the foulant from skim milk was removed, as compared to 60% for the milk/plant protein blend after the initial water rinse. Ultimately, the NaOH cleaning solution completely removed the foulant from the stainless-steel sensor surface.

The results of the investigation indicate that foulant removal by water differed significantly based on the temperature and concentration of the milk/protein blend. The influence of temperatures during creation and removal of the foulant are important for beverages containing plant proteins.

Special Session Fouling & cleaning

Oral

Cleaning of simple cohesive soil layers in a radial flow cell and slit flow cleaning cell

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Periodic cleaning is essential for preventing cross-contamination and restoring operational efficiency in food and beverage manufacturing. Optimising a Cleaning-in-Place system requires a good understanding of the cleaning fluid behaviour in a particular flow configuration and reliable knowledge of how the soil is removed. Computational fluid dynamics (CFD) can provide high-quality information about industrially relevant flows which arise in complex geometries that would be inaccessible through experimentation alone. Current efforts are directed at identifying and quantifying the combinations of parameters that determine cleaning via studies using model soils.

This work compares experimental cleaning studies conducted using two simple geometries, namely a radial flow cell (RFC) and a slit flow cleaning cell (SFCC) featuring flow along a rectangular channel with a 10:1 aspect ratio Both geometries can be reliably simulated using CFD and results compared favourably with published studies. The rigs were fabricated from polymethyl methacrylate (PMMA), allowing optical access for visual monitoring and quantification of soil removal. Despite its simple geometry, flow in an RFC is characterised by several recirculation zones at larger Reynolds numbers with larger gaps: these are absent in an SFCC, while the latter allows soil removal to be studied under turbulent conditions. These cells were used to study the kinetics of removal of two different, thin (up to 250 µm), dried soil layers of (a) instant coffee (governed by diffusive mass transfer) and (b) an abrasive domestic cleaning product (governed by the dissolution of the matrix and particulate removal).

The local soil removal rates and cleaning behaviour were quantified. The presence and size of particles influenced the removal kinetics, as did the surface roughness, chemistry, and flow structures. High-fidelity 2D axisymmetric (RFC) and asymmetric (SFCC) coupled CFD-species transport models were developed using ANSYS Fluent™. When compared with the experimental data, results from the CFD were found to give reasonably good estimates of the local mass transfer rates.

Special Session Fouling & cleaning

Oral

Foam flow cleaning of surfaces contaminated by Bacillus spores: impact of complex geometries mimicking food equipment

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The use of foam flow could represent an interesting alternative to conventional cleaning procedures in place for the cleaning of equipment surfaces contaminated by bacterial deposits, as equipment hygiene remains a major concern for the food industry. In this context, cleaning with wet foam (0.5 air/water fraction) has been proposed as an innovative method for cleaning closed equipment generating mechanical actions comparable to conventional procedures with a better efficiency in removing Bacillus spores.
A comparison between foam flow cleaning and standard cleaning-in-place (at the same shear stress 10 Pa, and using the same SDS surfactant (Sodium Dodecyl Sulfate 0.15% w/w)) was performed to test the potential of this novel approach to improve the cleaning efficiency of 2B stainless steel surface soiled by Bacillus subtilis PY79 spores. In the case of a straight pipe, the detachment of spores using foam flow resulted in about 3.6 log CFU reduction after 20 min cleaning compared to around 2 log CFU with CIP. In addition, a Life Cycle Assessment study shows that foam flow cleaning has significant benefits on the environmental impacts (around 90% less than CIP) with a drastic reduction in water and energy consumption.
In order to investigate the feasibility of using this method to clean actual food equipment, the first step was to assess how the effectiveness of cleaning by foam flow could be affected as a result of passing through various geometries. Various singularities widely encountered in food equipment design, such as the elbow, sudden expansion-contraction and check valve, were chosen. Compared to a straight pipe, the cleaning efficiency could be reduced by more than 1 log. However, it seems that depending on the singularity, this reduction in cleaning efficiency is more or less important. Indeed, these differences seem to be linked to the induced modifications of the size and organisation of the bubbles and on the stability of the foam itself.

Special Session Fouling & cleaning

Oral

Interfacial interaction: the fifth element of Sinners Circle

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Temperature, time, chemistry, and mechanical action are the four factors that dermine surface cleaning effeciency and economic return, as defined by the Sinner's circle. It is a principle applied in a broad spectrum of cleaning applications across multiple length scales.

From a tribological persepective, cleaning upon mechanical action is a wear process that is controlled by the interfacial interaction. A customised mechanical tester, coupled with a visulisation system, was used to quantitatively measure the frictional force experienced by a porous cleaning device, which enables us to establish real time correlation between
friction and cleaning kinetics as a function of solvent quality. Atomic Force Microscopy (AFM) and X-Ray Tomography were deployed the structural characteristics and surface interaction of the cleaning devices, respectively.

Our results show that the Coefficient of Friction is closely correlated with the cleaning process, subject to whether and how quickly the solvent involved could migrate into the surface foulant. Most importantly, we found that the interfacial interaction, measured by AFM based Force Spectroscopy, plays a vital role in surface cleaning: a non-polar solvent can significantly delay (or completely inhibit) the surface cleaning. This finding was not only evidenced by the nanoscopic surface adhesion data of a set of solvent-surface combinations, but the corresponding macroscopic cleaning actions captured by the camera. To further demonstrate our finding, solvents of varied viscosity were introduced as the cleaning medium, which showed consistent result to the non-polar solvent. The findings suggest that interfacial interaction could be an effective lever in delivering sustainable cleaning where less water, less chemical are used to conclude an increased degree of cleaning.

Special Session Fouling & cleaning

Oral

Extension of a classification scheme for cleaning mechanisms from steady to unsteady data and application to further soils

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Cleaning is an important process step in the food industry, especially to avoid contamination during increasingly frequent product changes. The machine equipment is cleaned almost daily therefore causing high ecological and economic expenses. An established approach to reduce these costs is conducting cleaning simulations, however, suitable models for the soils must be chosen. The appropriate model depends on the cleaning behaviour of the soil, i.e., the cleaning mechanism active in a particular situation.
In the recent past, the authors developed a neural network based approach to identify the governing cleaning mechanism from experimental data. The neural networks were trained and validated with model soils representing a given cleaning mechanism in prototypical manner. In the present work, the model is applied to realistic soils and the cleaning mechanism is determined with respect to varying operating conditions, like type of cleaning fluid, temperature of cleaning fluid, and flow velocities. Furthermore, a time-resolved determination of the cleaning mechanism is targeted. This requires extension towards machine learning methods that can handle time series data efficiently. These results will be used to draw conclusions on how suitable cleaning simulations of the investigated soils could be conducted.

Special Session Fouling & cleaning

Oral

Fouling of Food-Contact Surfaces; Scale-up Parameters

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The fouling of food-contact surfaces has negative impact on several aspects of food manufacturing operations. The most direct impacts are reduced efficiency of heat exchangers, and lower product production rates. These factors emphasize the need for an improved understanding of the fundamental mechanisms of fouling. The potential for use of nanoscale sensing of fouling as provided by quartz crystal microbalance with dissipation (QCM-D) is very appealing, but the scale-up of outcome parameters must be established. The objective of this research was to demonstrate the ability to use outcomes from nanoscale experiments to predict outcomes from pilot-scale operations for milk protein beverages.

A series of experiments have been conducted to evaluate the magnitude and composition of foulants from samples containing milk proteins when heated to temperatures between 65 and 132 C. The experiments were conducted with a High-Pressure-High Temperature (HPHT) QCM-D, and with a pilot scale UHT system containing strategically located temperature and pressure sensors. The results demonstrated a distinct relationship between the magnitude and composition of foulants on nanoscale sensors as compared to fouling on surfaces in a pilot-scale system. The topography of foulants at both scales indicated that surface finish is important when evaluating scale-up results from HTHP-QCM-D to pilot scale experiments. The influence of temperature on rate of fouling was similar for experiments conducted at both scales. Overall, these results support the use of HPHT QCM-D for the study of fouling for scale-up to pilot- and industrial-scales.

Special Session Fouling & cleaning

Oral

Design of biomimetic coatings to mitigate dairy fouling

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In food processing industries, products and especially dairy products undergo thermal treatments (pasteurization, sterilization) leading to fouling formation on heat exchangers' surfaces. These deposits can contaminate dairy products during pasteurization process and also impair heat transfer mechanism by creating a thermal resistance, thus leading to regular shut down of the processes. Therefore, periodic and drastic cleaning-in-place (CIP) procedures are implemented. These CIP involve the use of chemicals and high amount of water, thus increasing environmental burden. It has been estimated that 80% of production costs are owed to dairy fouling deposit.
To reduce dairy fouling, two pathways have been considered: (i) Process conditions optimization, mainly tested by food-processing industries and (ii) Stainless steel surface anti-fouling or fouling-release coating to either inhibit attachment of depositing species or to ease their removal during cleaning respectively.
In our team, we focus on this latter approach by developing biomimetic coatings (slippery liquid-infused surfaces (SLIS) and atmospheric plasma nano-structured coatings) of low contact angle hysteresis to limit fouling adhesion onto stainless steel surfaces. Slippery liquid-infused surfaces are inspired by Nepenthes plant by designing slippery interface between the substrate and the fouling providing fouling-release surfaces. Slippery surfaces were elaborated in three steps: (i) femto laser surface structuring, (ii) silanization and (iii) lubricant impregnation. In order to maximize lubricant retention, laser manufacturing parameters were optimized.
Plasma nano-structured coatings intend to mimic lotus leave surfaces, by creating a dual-scale roughness preventing adhesion of denatured dairy proteins. Hydrophobic multilayer silane/fluorosilane based coatings were sprayed by atmospheric pressure plasma (ULS, Axcys Technologies) and conditions were optimized depending on the fouling test results obtained.

Special Session Fouling & cleaning

Oral

Surface effects in fouling and cleaning

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Fouling is the process by which surfaces become contaminated by other species. This can happen inside process plant, on the surfaces of food factories, and in the home. Fouling is a multiscale process; deposits form as the result of nano-scale interactions between deposit and surface, which scales up to the formation of mm-cm scale deposits on m-scale plant or surfaces.

Cleaning depends on the breakage of the bonds between surface and foulant, carried out by physical and chemical processes. The control and/ot understanding of interfacial behaviour is critical in cleaning. There has been extensive research on creating surfaces that have controlled interfacial proeprties, that can resist fouling or speed cleaning. These surfaces can be effective over small areas or in well-controlled situations, but it has not been possible to make fouling resistant surfaces that work for the time required for plant operation.

This presentation will review recent work in nano- to meso- scale fouling and cleaning research, demonstrating how better understanding of how materials adhere or are removed from surfaces could lead to new processes that are easier to clean, and thus use less energy and water in operation.

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Special Session Fouling & cleaning

Oral

Feedback Control of the Food Quality Trajectory Using In-Package Sensing and a Process-As-You-Go Approach

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Food preservation typically involves a single kill step followed by isolation of the product within a package, with passive hurdles or no further treatment: an open-loop approach to control food quality. An alternative vision is that of a closed-loop food control strategy, wherein the food is moderately processed as an initial stabilization (first kill-step) but the option for processing later as-needed is built into packages by implanting processing means within packages, and including sensors within the package, so that additional intervention steps are possible. We tested apple juice within electrode-embedded pouches with four main lines of samples. The first set (A) were moderately processed, cooled and held at 4ºC for the storage period. The second set (B) was subjected to the same process but monitored for microbiological counts, sensory quality and impedance during 4ºC storage, and processed either when sensory evaluation or microbiological counts suggested a need). The third set (C) was subjected to a mild conventional thermal pasteurization, and held without further processing, but evaluated for sensory quality, impedance and microbiological counts.

Raw samples fermented and spoiled quickly; pasteurized (C) samples showed decreasing counts during going below detectable limits within 2 weeks; the sample moderately processed once (A), showed microbiological recovery, and spoiled by 4 weeks; samples moderately reprocessed (B) had microbiota (mostly yeasts) that tended to recover after first processing, but were further reduced during reprocessing.

Sensory evaluation, scoring samples on visual and aroma attributes showed that the reprocessed samples (B) showed significantly superior scores on selected positive attributes; and maintained at least as good quality as the pasteurized samples (C) over storage. Reprocessing successfully staved off spoilage. In the later weeks, samples from the B and C groups also showed significantly superior attributes to commercial apple juice. We have also further investigated the potential for in-package sensing for food quality attributes. In particular, the variance in the rate of change of product impedance appeared to be a promising signature for impending spoilage. Reprocessing at this stage stabilized the impedance.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

Effect of high pressure on structure and nutritional properties of raw salmon flesh

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Keywords: high pressure, salmon, structure, protein,

Atlantic salmon (*Salmo salar*) is one of the most eaten fish in Europe, known for its high unsaturated fatty acid and protein content. However, it is a fragile product, which after slaughter is rapidly altered by chemical, enzymatic and microbiological phenomena. In this context, high pressure can be used for preserving this product.

High pressure can alter the properties of the macromolecules, particularly proteins, which account for almost 70% of the dry matter in salmon. The alteration of these molecules by high-pressure treatment can therefore alter the nutritional and organoleptic properties of the product.
Understanding the biochemical mechanisms that lead to changes in the characteristics of salmon could make it possible to control the high-pressure process to improve the shelf life of salmon without affecting consumer acceptability, or conversely to use the new properties of salmon proteins and muscle to elaborate innovative products.

This study aims to evaluate the effect of high pressure treatments on salmon proteins, in order to explain the consequences of the process on its organoleptic and nutritional qualities.
The effect of high pressure on muscle microstructure, color and protein digestion was studied.
Results show a reduction in the size of the fibres and an increase in the size of the extracellular spaces. In addition, pressure induces an increase in protein oxidation rate and modifications of tertiary and secondary structures. The quantity of helix-α structures is reduced by the pressure in correlation with an increase in aggregated β-sheets. With regard to in vitro pepsic digestion, treatments at 600 MPa increase the maximum digestion rate and reduces the half-digestion time from 200 MPa. Moreover, pressure has little effect on the proportion of different amino acids.

This study highlighted changes in protein structure and digestion of salmon fillet after high-pressure treatment.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

Pasteurization of food and beverages by high pressure processing (HPP) at room temperature: Inactivation of Staphylococcus aureus, Escherichia coli, Listeria monocytogenes, Salmonella and other microbial pathogens

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Vegetative pathogens are actively growing, metabolizing and dividing cells in foods, and consequently the focus of concern for food industry, food regulators and food control agencies. Foodborne outbreaks continue to be reported around the world, causing illnesses, hospitalizations and in certain cases deaths, together with product recalls and subsequent economic losses. Major bacterial infections from raw and processed foods are caused by the toxigenic *Escherichia coli* serotype O157:H7, *Salmonella enteritidis* and *Listeria monocytogenes*. High pressure processing (HPP) is a non-thermal pasteurization technology which relies on very high pressures (400-600 MPa) to inactivate pathogens, instead of heat, thus causing less negative impact on the food nutrients and quality. It can be used to preserve foods instead of chemical food additives. In this study a review of the effect of HPP treatments on major vegetative bacteria in specific foods was carried out. HPP at 600 MPa, commonly used by the food industry, can achieve the recommended 5-8 log reductions in *E. coli, S. enteritidis, L. monocytogenes* and *Vibrio*. *Staphylococcus aureus* presented the highest resistance among the foodborne vegetative pathogens investigated. Following in resistance to HPP was *E. coli.* More susceptible *L. monocytogenes* and *Salmonella* spp. bacteria were reduced by 6 log at pressures within 500-600 MPa. *Vibrio* spp. (e.g. raw oysters), *Campylobacter jejuni, Yersinia enterocolitica, Citrobacter freundii,* and *Aeromonas hydrophila*, generally required lower pressures (300-400 MPa) for inactivation. Bacterial species and strain, and the food itself with a characteristic composition, affect the microbial inactivation. This review demonstrated HPP is a safe pasteurization technology, able to achieve at least 5 log reductions in major food bacterial pathogens without application of heat.
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Special Session; HPTP, state of the art and its future in the food industry?

Oral

International Laws and Regulations Impacting the Commercial Uptake and use of High Pressure Thermal Processing for Human Food

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The global regulatory landscape relating to food and food preservation technology is exceedingly complex. Successfully navigating this nuanced dominion with the view to commercializing novel preservation methods can be an especially daunting challenge. The regulations for many countries pertaining to the uptake of novel technologies are based on the “precautionary principle.” Other countries, including the US, are increasingly demanding a complete assessment of risk before novel processing and preservation methods can be utilized in the production of foods intended for human consumption. Also, to be considered in this complicated morass of rules and laws are the public health implications, posed by those nations where legislation and regulations relative to novel technologies are mute or simply nonexistent.
This chapter provides an overview of emerging regulatory trends and legislative developments, globally, that are likely to impact the procedures and protocols that are demanded for obtaining the necessary approvals for allowing the commercial uptake and use of high Hydrostatic Pressure Thermal Processing (HTPT) as an accepted preservation technique for use in the production of human food.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

High Pressure Thermal Processing (HPTP) Systems

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High pressure thermal processing (HPTP), defined as the combination of pressure (400-600 MPa) and above ambient temperature levels (40-130°C), can reduce the negative impacts of thermal processing by minimizing the exposure of products to high-temperature levels. However, HPTP systems are not widely available, with most of these systems being laboratory-scale units and only a handful of pilot-scale units worldwide. Laboratory-scale units have vertical vessels with a small volume (0.1-4 L) and/or narrow vessel diameter. Consequently, many of these machines are unable to process food products in packaging formats used by industry processors. HPTP machines share most of their fundamental components, configuration, and operation with industrial high pressure processing (HPP) units (55-525 L) operating at chilled or room temperature (4-25 °C). There are pilot plant units (35-135 L) reaching up to 700 MPa and 130°C. Still, some technical and operational limitations hold back the commercialization and industrial implementation of HPHT such as accurately controlling and monitoring temperature under pressure, scaling-up issues, validation challenges, productivity, and high capital and/or operational costs. Progress has been made in recent years to facilitate the adoption of this technology, thanks to the use of standard HPP machines with insulated carriers/baskets. These carriers contain the preheated products and carry them into the high pressure vessel. They minimize heat loss of the heated product with the pressurizing fluid, vessel wall, or plugs during the pressurization cycle. The insulated carriers also protect the components of high pressure equipment from high-temperature levels, allowing HPTP processing in existing nonthermal high pressure machines for the commercial development of foods, and other applications in the pharmaceutic and biomedical industry.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

High pressure thermal processing and pressure assisted thermal sterilization – an overview

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High pressure thermal processing aims to improve food safety and food quality by elimination of spoilage organisms and foodborne pathogens through application of pressure at a temperature of 40 °C to 121 °C. The term high pressure thermal processing (HPTP) refers to processes that employ high hydrostatic pressure at 40 – 100 °C to target vegetative cells of bacterial foodborne pathogens as well as spores of bacterial or fungal spoilage organisms. Processes that operate at high pressure and 110 – 121 °C to eliminate bacterial endospores of concern for food safety or food spoilage and are referred to as pressure assisted thermal sterilization (PATS). This presentation aims to provide an overview on key developments that facilitated the introduction of high pressure processing to industrial food production as well as key discoveries related to high pressure thermal processing and pressure assisted thermal sterilization. Based on currently available data, the science on what can or cannot be achieved with high pressure thermal processing or pressure assisted thermal sterilization is largely available. In addition, food engineering provided the technology to deliver equipment for commercial scale high pressure thermal processing or pressure assisted thermal sterilization.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

HPTS and its effect on production of food processing contaminants and quality-related properties in food in comparison to thermal-only processing

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High pressure in combination with high temperatures is an innovative and emerging technology to efficiently sterilize low acid food products over a long shelf-life. In this regard it is crucial to inactivate all pathogenic vegetative microorganism and in particular spore former and endospores, respectively. Compared to commercial sterilization techniques, with long dwell times and subsequent extensive heat impact, the additional pressure application enables faster heating and cooling rates and instantaneous heating throughout the whole product. Therefore, a less harsh impact on nutritional and sensorial qualities is generally attributed to the so-called High Pressure Thermal Sterilization (HPTS) by researchers, ideally resulting in a better overall quality of the food product. This work focuses on the comparison of thermal-only sterilization and high- pressure thermal treatment on theoretical basis, particularly affecting microbial stability, selected vitamins and bioactive compounds, colouring pigments, and food processing contaminants. Findings indicate that the additional pressure application can beneficially improve selected quality-related attributes, e.g. reduced formation of food processing contaminants like furan. Consequently, a higher quality product for consumer is attributed. Nevertheless, the research work also revealed that it is not always possible to retain quality attributes in equal measure, regardless of the promising advantages of HPTS. Fine-tuning of the process parameters pressure, temperature and time is therefore mandatory to reach both goals, microbial stability and high quality.

Special Session; HPTP, state of the art and its future in the food industry?

Oral

Computational modelling and engineering aspects of High Pressure Thermal Processing

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Computational modelling and engineering aspects of High Pressure Thermal Processing
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Submission for oral presentation in special session on HPTP

Innovative food processing technologies, such as high pressure processing at low and elevated to high temperatures, have gained increasing interest over the last decade as they can be applied to manufacture safe foods with better sensory and nutritional properties, and in fact induce textural changes in the product that can not be achieved by any other means. While high pressure processing at low temperatures (HPP) has been commercially applied for >15 years, high pressure thermal processing (HPTP) is yet to be commercialised due to the lack of equipment available that operates at high temperatures and industrial scale. HPTP has been hailed as the next disruptive technology in the food industry and will play an important role towards satisfying consumer demand for high quality, safe and innovative products. Computational Fluid Dynamics (CFD) has been established as a tool for characterising, improving, and optimising traditional food processing technologies; innovative technologies, however, provide additional complexity and challenges because of the interacting Multiphysics phenomena. This article will highlight Multiphysics modelling case studies, mainly from the authors institution, for the characterisation of various processing aspects and optimisation of HPTP.

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

How to involve the stakeholders in the sustainability assessment process of a technology or food value chain

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The transition towards a more sustainable food system requires that small and mid-sized enterprises increase their economic competitiveness and resilience and strengthen their innovation capacity. However, their specific needs are often neglected, especially in innovation processes that often focus on large and expensive improvements.
The H2020 project FAIRCHAIN (https://www.fairchain-h2020.eu/) proposes development and adaptation of innovations that strengthen the position of small and mid-sized farmers and processors in the food chains and allow the scale-up and expansion of the production of nutritious food at a regional level. FAIRCHAIN has developed a methodology to encourage putting technological innovations for food producers and food SMEs into practise through resilient and sustainable food value chains. This methodology is based on a co-creation process and an assessment framework in which stakeholders participate in the definition of the assessment indicators.
This talk will present the methodology developped and will illustrate it with some technical and technological innovations devoted to SMEs and producers which may increase food sustainability: as examples the development of an innovative healthy fermented whey-based drink to upgrade the value of whey, a co-product of cheese manufacture ; the development of an innovative packaging machine for liquid or viscous food products in the dairy and fruit & vegetables and dairy sectors, using green or sustainable packaging materials and designed to fulfil hygienic requirements ; or the development of the blockchain technology for a feta production chain, to improve the traceability , transparence and information sharing, that is of major importance when increasing the number of intermediaries in the food chain.
The benefits of the proposed co-creation process and assessment framework will be presented. Key challenges to innovation adoption (identified thanks to the co-creation process and assessment framework) will be discussed, as well as factors supporting and hindering innovation uptake and possible solutions for successful implementation.

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ICEF14 INTERNATIONAL CONGRESS ON ENGINEERING AND FOOD
June 20-23, 2023
LA CITÉ DES CONGRÈS
NANTES - FRANCE

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

Environmental, Social, and Economic Sustainability Assessment of Food Production Systems

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THIS ABSTRACT IS PART OF THE ACCEPTED SPECIAL SESSION (Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies)

Food systems are at the heart of the 17 Sustainable Development Goals (SDGs). The wide scope of the SDGs call for holistic approaches that integrate 'siloed' food sustainability assessments. Here we present a global scale analysis quantifying the status of national food system performance of 156 countries, employing 25 sustainability indicators across seven domains: nutrition, environment, food affordability & availability, sociocultural wellbeing, resilience, food safety, and waste.
We assess the nutritional quality of average national daily diet taking into account >25 essential nutrients and several nutrients of health concern in the consumed food items and their daily dietary reference intakes and maximum reference values, respectively. Next, we compile the environmental footprint through recently proposed approaches in life cycle assessment. The results show that high-income nations score well on most indicators, but poorly on environmental, food waste and health sensitive nutrient intake indicators. Transitioning from animal foods towards plant-based foods would improve indicator scores for most countries.
Focusing on a food product level, nutritional combined life cycle sustainability assessment, aligned with the emerging process developments, can evaluate the suggested solutions on a multi parameter base in terms of sustainability of improved food production. The integration of advanced life cycle assessment with nutritional metrics can provide the first assessment of the real value for the innovative food products currently developed. In this product level comparison, we calculate nutritional adequacy and diversity metrics for over 200 foods and countries. Environmental impacts of food products change when measured on a nutritional basis. Food products can also cover nutritional deficiencies in an environmentally friendly way.
These assessments allow for an improved and more fair comparison between new food products against benchmark sources, taking into consideration the additional respective technology readiness levels of emerging processes.
Our quantitative multi-indicator sustainability assessments can help food producers and policymakers to set improvement targets on specific areas and adopt practices while keeping track of their holistic sustainability performance.

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

Dynamic weighting model of environmental impacts of food systems

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THIS ABSTRACT IS PART OF THE ACCEPTED SPECIAL SESSION (Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies)

Dynamic and accurate assessment of environmental impacts of products in relation to national and regional conditions is important for the development of efficient mitigation strategies and policies. Available weighting methods in life cycle assessment rate environmental burdens based on survey- and panel-based approaches. Moreover, the importance of weighted values in relation to current state or environment carrying capacity is not known. It is especially obvious when the weighting is performed for emerging protein products or different regions or performed for the novel protein products like insect or microalgae. Taking the approach of weighting the characterized environmental impacts against the total impacts or impact of specific production chains on a country or regional level allowed to determine their current state importance of environmental influence. Among compared countries, proposed weights based on total national impact, available arable land and country population were the highest for Saudi Arabia and Japan and lowest for China and India. Weights based on impact of protein production supply, arable land and population were more relevant to emerging protein products indicating higher potential impact for Saudi Arabia and Japan. For example, the global warming impact of Acheta domesticus (crickets) as a novel protein source weighted against the impact of total protein supply, available arable lands and population indicated more than 60 times higher eco-potential impacts for India than for Saudi Arabia and Japan, and only 2 times higher than potential impact in the USA, China and Russian Federation. The weights have a dynamic annual resolution and thus represents a sensitive approach for precise disclosure of environmental impact of a product in relation to the current state of environmental influence. They can be used as an-biased explainable weighting factors for the sustainability assessment of products, providing a valuable insight for the research, industry and policymaking.

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

Multi-objective optimization of food and feed production chains (with a case study on insects)

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When considering the optimization of a production chain for food and feed, it is immediately noticeable how no single best solution exists: multiple conflicting objectives need to be balanced and evaluated. Such objectives include economical assessments (costs for energy and feed, capital expenditure, annual production, etc.), sustainability goals (consumption of water, use of chemicals, production of wastewater, GHG emissions, etc.) and societal impacts (number and quality of new jobs created, safety measures for employees, societal acceptance of insect farming, etc.). Rather than aggregating all optimization objectives into one, for example by using a classical weighted sum, a more unbiased approach is multi-objective optimization (MOO). In place of a single solution, MOO algorithms are able to deliver a set of different compromises, each one favoring some objectives against others. By showing the available optimal trade-offs to human experts, MOO makes it possible to explore different scenarios and ultimately make informed choices, visualizing what can be gained and lost by choosing one particular solution over others. The case study considered in this work is a production chain of insects for feed. In order to apply MOO to sustainable insect chains, we identified several objectives for which either computer/mathematical models are readily available, or for which machine learning models can be inferred from data collected by partners in the project. The long-term objective is to provide both private and public stakeholders with different possibilities for the configuration of modern insect production chains.

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

Enhancing the Sustainability Outlook through Upcycling of co/by-product: A Case of Fruits and Vegetable Production Value Chain in Canada

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Supposedly, the current global food production capacity cannot compensate for the food demand of the perpetually growing global population. This growth will require a 60-70% increase in food production by 2050. Hence, interventions, production and processing pathways and food system framework developments are needed to enhance the current food value chain while operating within a safe and healthy planetary space. In achieving this, the circularity and upcycling of biological and technical resources have played a critical role. However, when it comes to biological resources, especially co/by-products and waste from process industries, the attention has been on either converting these co/by-product and waste streams into value-added products or reinserting them into the value cycle without considering the sustainability implications. In achieving this, all supply chain members should be involved to accelerate the transition to a circular economy, and collaboration is crucial. In this regard, food processing and production industries play crucial roles in the sustainability transition at multiple levels within the food value chain, especially in adding value to highly perishable and less containable raw materials. This study, in collaboration with a food process industry in Canada, explores the upcycling potential of co/by-products from the primary process. A Life Cycle Sustainability Assessment is conducted to determine the implications of the identified upcycling opportunities. The study results were integrated into an interactive dashboard, Circular Bio-economy StartKit, to enable stakeholders to explore and visualize "what if scenarios". The Circular Bio-economy StartKit allows a broader system-level analysis considering the stakeholder decision's economics, environmental, and social implications of selected co/by-products. Additionally, it enables stakeholders to gain access to an in-house decision support system that allows multiple trade-off analyses across different upcycling pathways for different co/by-products. The proposed approach to the Circular Bio-economy StartKit could be extended to other process industries within the food sector.

Special Session; Multi-Indicator Sustainability Assessment of Food Systems, Products, and Food Process Technologies?

Oral

Valorisation of plant coproducts: characterisation and implementation of a prioritisation methodology using multi-criteria analysis

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Plant co-products have a great potential for recovery as secondary materials. Despite their enormous potential, only a small percentage of these co-products are recovered, which has negative social, economic and environmental impacts. However, the viability of recovery alternatives depends on a number of criteria. It is therefore necessary to be able to list all the criteria to be taken into account and the possible ways of application. A methodology has been established to develop a multi-criteria analysis. This analysis uses the AHP (Analytic Hierarchy Process) method and the fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method to weight the criteria and rank the recovery routes studied. Banana co-products and their recovery routes were taken as a case study. These co-products were analysed on the basis of 4 criteria, 23 sub-criteria and 136 recovery alternatives. The analysis was applied to 2 matrices: one general (by co-product) and the other more specific (by application pathway).
The combination of the bibliographic characterisation of the co-products and their matrix analysis made it possible to demonstrate their richness in nutrients and bioactive components, associated with interesting uses in nutrition and health. The method made it possible to evaluate engineering, product quality, economic and environmental criteria, of which the sub-criteria of legislative feasibility and toxicity had the greatest impact in the classification of co-products.
The most interesting recovery routes are obtaining fatty acids by fermentation and extracting bioactive components. This multi-criteria approach can be used to manage co-product recovery options.

Special Session Plant proteins

Oral

Supply chain and engineering opportunities for plant-based ingredients in Australia

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Australia currently exports USD 9B worth of grains, oilseeds, and pulses. At the same time, many Australian plant-based ventures must rely on imported plant-based ingredients from grains like soybean, pea or chickpea as Australia has small capacity for local manufacturing. This presentation will cover the efforts carried out Australia-wide in manufacturing plant-based ingredients including flours, concentrates and isolates. It will highlight the engineering challenges and regional solutions achievable when scaling up wet and dry fractionation from laboratory to commercial scale. It will provide case studies of ingredient companies developing or manufacturing ingredients from regional grains, oilseeds, and pulses.

Special Session Plant proteins

Oral

Transforming by-products of plant protein production for a sustainable and cost effective ingredients manufacturing

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Surge of negative environmental evidence of impact over production and consumption of animal proteins over the last few years has been a major driver to look for sustainable alternatives. Due to industry and consumer demands, plant protein production in Australia and more broadly has increased rapidly in recent years, and it is projected to grow even further over the next decade.
The main raw material used in the Australian plant protein production is pulses. However, most pulses only contain 25-30% protein, a large proportion is non-protein components, therefore large quantities of waste are generated (about 3 kg dry waste per 1 kg plant protein) and make these processes economically challenging. More importantly creating large quantities of wastes makes the existing plant protein production from pulses unsustainable. Global growth in demand for plant protein is seen to be a long-term market trend and hence its related waste can be even higher as the Australian and global pulse production has the capacity to support higher plant protein production. However, waste streams are seen as a major hurdle against further expansion of plant protein production.
Current industry challenges and strategies in dealing with the waste streams of plant protein production will be critically analysed and reviewed. Challenges and possible solutions of large-scale processing of plant protein production wastes will be addressed.
With an industry lens, engineering opportunities for large scale recovery and transformation of waste streams into functional as well as health promoting food ingredients will be discussed.
In particular, process options for recovering premium quality starch and invisible pulse fibre from plant protein production wastes are highlighted. Transformation of the extracted products into value added and healthy ingredients such as soluble and insoluble dietary fibres, special purpose starches, fat replacers and invisible fibre through physical and other approved/green technologies for food and non-food applications are reviewed.

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Special Session Plant proteins

Oral

Leaf protein from pasture – A New Zealand Opportunity

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New Zealand's ability to produce high quality, animal-derived protein ingredients is globally recognised. However, this capability has yet to be leveraged for the production of high-quality plant-derived alternatives. The New Zealand Institute for Plant and Food Research Limited (Plant & Food Research) has investigated emerging plant protein opportunities for the New Zealand environment. This is a complex subject, and our research has been aimed at tackling key fundamental questions:

- What crops can be sustainably and competitively produced and processed into protein ingredients?
- What are the processing technology challenges and opportunities?
- How do concepts stack up economically and how can they work synergistically with existing farm systems?
- What are the nutritional and functional qualities of different plant-protein products?

Our work has identified and prioritised multiple crop types that have potential as feed stocks for a plant protein food ingredient industry under conditions prevailing in New Zealand. Of the crops evaluated, the leafy pasture crops, particularly alfalfa, ryegrass, and other cereal crops, are likely to be the most successful, given our natural advantages in growing these. The supply benchmark was set based on initial estimates for the minimum feedstock needed to support a commercial factory and to ensure there was an adequate supply to support development of an export market. Our early research suggested that efficient high-yielding processes are critical, and now our focus is the pilot-plant scale-up work necessary for commercial success.

Special Session Plant proteins

Oral

Challenges and Opportunities in Plant-based Protein Manufacturing

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The growing demand in plant-based beverages and foods, such as yogurt and cheese, drives food processors to seek innovative approaches to convert plant protein ingredients into novel food products with desired functionalities. The composition and characteristics of plant-based proteins, however, are different to proteins from animal sources (e.g., dairy and meat), presenting many challenges alongside the opportunities of plant-based product manufacturing. This presentation will showcase recent work within The Department of Chemical Engineering Food and Agribusiness Program and within Agriculture and Food at The University of Melbourne, highlighting how research is addressing some of these challenges, including:

(i) Membrane Processing of Plant-based Milk - Membrane systems are widely used for the fractionation and concentration of dairy proteins, to avoid the degradation of heat-sensitive compounds and the loss of their bioactive properties. Only a limited number of studies, however, have focused on membrane filtration of plant-based proteins. We investigate the filtration mechanism and fouling propensity for ultrafiltration of common plant-based milk (e.g., soy milk), in terms of critical flux and gelation concentration. We discuss how a fundamental understanding of protein filtration developed through studies of dairy systems can be applied to the ultrafiltration of plant-based proteins, and the strategies for mitigating membrane fouling in industrial operations.

(ii) Almond Protein Gelation - The development of plant-based products requires a better understanding of the response of plant-based proteins to process variables. Challenges are also introduced by the reduced protein content of these products compared to dairy products. We present the effect of pH and thermal treatment on the microstructure of almond proteins. Moderate heating (55°C and 75 °C) induces denaturation and partial aggregation, while a self-supporting weakly flocculated particulate gel structure can be formed at higher temperatures. Gels formed at pH 4 and 7 are similar in strength but differ in their textural properties, illustrating how almond processing can be tailored to obtain products with desired properties for enhanced consumer acceptability.

Special Session Plant proteins

Oral

Assessing the Industrial Eco-efficiency of Pea Protein Extraction by the Hybrid Fractionation Method through a Techno-eco-environmental Analysis

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Global plant-protein demand is dramatically increasing, which has informed the need to expedite protein production towards enhancing plant-protein supply, with peas being the most exploited plant protein source due to their large production market. Aside from the present dry and wet fractionation process currently adopted, there is the hybrid fractionation method, a newly evolving method that has been proven sustainable and produces high-quality protein isolates (75-85%). However, little effort has been made to assess the economic and environmental implications of upscaling and economy-wide adoption of the hybrid fractionation method. This study uses the superstructure approach to explore candidate hybrid fractionation configurations (HFC). The superstructure design of HFCs was based on different combinations of wet and dry methods and varying pre-treatment and pre-classification methods. Wet and dry methods consisted of milling, extraction, centrifugation, precipitation and drying. The performances of the selected HFC scenarios were evaluated using an integrated Life Cycle Assessment-Techno-Economic Assessment (LCA-TEA) environment. First, the HFC scenarios were simulated in SuperPro Design software to carry out the material and energy balances and assess their technical and economic efficiencies. This was followed by an environmental LCA using OpenLCA v1.11. Finally, the results were integrated to exploit the inherent LCA-TEA trade-offs using Data Envelopment Analysis. The proposed approach allows for a more accurate sustainability comparison for different HFCs. In addition, sensitivity and uncertainty analyses were carried out to assess the critical parameters of the most significant influence. The results provide invaluable insights into the technical, economic, and environmental trade-offs to permit more informed decisions on the industrial adoption of the optimal HFC for sustainable pea-protein extraction. Going forward, the findings from this analysis would be critical for stakeholders, including industrial pea protein processors, protein extraction researchers and policymakers

Special Session Plant proteins

Oral

Protein enrichment of plant meals and side-streams by dry triboelectric separation

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The aim of the present study was to produce protein concentrates from deoiled lupine flakes (DLF), rapeseed press cake (RPC) and sunflower press cake (SPC) using triboelectric separation. The focus was on the raw material pre-treatment and optimisation of the process parameters to maximize protein enrichment and yield. DLF, RPC and SPC with different oil contents were pin- milled to different particle sizes and subsequently fractionated using a triboelectric belt separator, resulting in a protein-rich (E2) and protein-depleted fraction (E1). The protein content of the raw material and the fractions produced were analysed using the Dumas method and the mass yield, protein enrichment and protein separation efficiency were calculated. Furthermore, the particle size distribution (PSD), proximate composition and colour were analysed. To determine the cellular components in both fractions, scanning electron microscopic (SEM) images were taken. The optimal process parameters were determined by multiple linear regression. Finally, the raw materials were tested in high-moisture extrusion.
Dry fractionation of the selected raw materials resulted in absolute protein enrichment of 6% for RPC, 20% for DLF, 6% for SPF and 9% for de-oiled SPF. The mass yield for each material tested was between 40 and 50%. Separation of the SPC with 20, 15 and 0% oil (dm) showed the highest protein enrichment for the de-oiled SPC. Smaller particle size of the raw material resulted in higher protein enrichment, as finer grinding, released more protein bodies from the cell matrix, which was confirmed by the PSD and SEM images of the separated fractions. The E2 fractions had a smaller particle size and protein bodies were visible on the SEM images, whereas the E1 fractions had a larger particle size and both hulls and cellular material were detectable on the SEM images.
Triboelectric separation proved to be a promising technology for dry fractionation of plant-based materials. Protein enrichment was best for the de-oiled raw materials with the smallest particle size, as de-oiling avoided agglomeration and fine grinding released the protein bodies sufficiently from the cellular matrix to be separated from the other components.

Special Session Plant proteins

Oral

Using non-thermal processing to develop novel structures

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In food industry, powders play an important role in manufacturing. The commonly used process used in an industrial level is spray drying. In this unit operation, the particles are exposed to heated air, with detrimental effects on thermosensitive ingredients, such as vitamins, colours and flavours that are present in the formulation. The energy consumption in spray dryers is very high (up to 13GJ/h with evaporation rates up to 4 tons/h). Given that, alternative processes that consume less energy and show a high retention of the inclusions is needed. In this context, electrospraying is an alternative process. Electrospraying is an emerging technology used to produce particles in the sub-micron scale. During this process, an electrical field is being created between polymer solution or emulsion and a grounded collector which leads to the production of particles. The whipping of the polymer jet caused by applying high voltage leads to solvent evaporation during the flight towards the collector. The fact that no heat is required, is especially interesting in the food manufacturing industry, as we will achieve higher retention of the colourings, vitamins and flavours. Comparing energy required for lab-scale process of spray-drying and electrospraying, shows that there is up to 20% reduction of the energy used. However the effect that the process has on the powder and on the starting solution is not fully understood. In this study we gain fundamental understanding of how the food materials (plant proteins and cellulose) interact during and after the processing and what influences the process optimization (material properties, flow rate, applied voltage, viscosity, and interfacial tension). The structural changes of proteins in solution, i.e. their aggregation or denaturation upon interaction with cellulose have been investigated by small and wide angle X-ray scattering. Viscosity and processing conditions showed to play a significant role on the particle’s microstructure and stability. Taking all the above into account, electrospraying is an emerging technology that can be used to reduce the energy consumption.

Special Session Plant proteins

Oral

Interfacial properties of pea and lupin protein ingredients: a pivotal effect of endogenous lipids and aqueous suspension pre-homogenization

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The incorporation of plant protein isolates or concentrates as functional ingredients in foods is a means to promote the transition from animal to vegetable proteins. Pea and lupin farming meet sustainability demands and their protein ingredients display promising nutritional properties, yet sometimes poor functionalities. However, the involved mechanisms are still unclear, partly because comprehensive and systematic characterization of those ingredients in terms of composition and physicochemical properties is still lacking. In this work, commercial protein isolate and concentrate of pea and lupin were first thoroughly characterized. A high-pressure homogenization (HPH) treatment was applied to their aqueous suspensions (pH 7.0) to alter their colloidal state and potentially improve their subsequent functionalities. Even though isolates displayed a higher protein content (about 70 wt.% against 40 wt.%), their solubility (defined as the protein fraction remaining in the supernatant after centrifugation) was lower than for the concentrates. Substantial amounts of endogenous lipids in the powders were measured by Folch extraction (from 3.5 to 11 wt.%), of which half were phospholipids, which can have important implications for the interfacial properties of the ingredients. Detailed microscopic investigations (including confocal fluorescence microscopy), as well as static and dynamic light scattering measurements showed that HPH was useful to break down undispersed powder grains, thus enhancing protein solubility and freeing endogenous lipid structures. The interfacial properties of the different suspensions were investigated with an automated drop tensiometer; in particular, oscillatory dilatational deformations of the oil-water interface were conducted to probe the interfacial rheological behaviour of the formed interfacial films. The raw data were analysed by Lissajous plots, which allow for obtaining insights into complex structural arrangements within the films. We have thereby been able to approach the repartition and potential competition between protein and phospholipids for the oil-water interface of ingredients with a complex composition. Those new insights into the non-protein composition and behaviour (in aqueous media and at the oil-water interface) of plant protein fractions are key for improving their functionalities and facilitating food products' rational formulation.

Special Session Plant proteins

Oral

Structure-function-application of plant proteins in meat and dairy analogues

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Plant proteins have complex structures at various lengths, which govern their application in plant-based protein foods, including meat and dairy analogues. This presentation provides the current understating of how the molecular size/weight, secondary structure, crystalline structure, charge, and presence of sulfhydryl and disulphide bonds affect the functionality (solubility, foaming, emulsion, gelling, pasting and rheological) of isolated proteins and how these are related to the property of high -moisture extrusion cooked meat and fermented dairy analogues prepared from lentils, mungbean and lupins compared to commercially available soy and pea proteins. Further, the effect of extraction and drying techniques on the techno-functional properties will be articulated. Finally, the manipulation of protein structure (e.g. extrusion conditions, non-thermal processing of proteins) for achieving the desired product functionality, e.g. texturization in meat analogues or firmness in dairy analogues, will be presented.

Special Session Plant proteins

Oral

Plant-based meats – engineering innovations and commercial opportunities

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The livestock industry is a major user of agricultural land, yet only produces approximately 16% of our food worldwide. It emits large quantities of nitrate, which can pollute ground water, and methane, which is a well-known greenhouse gas. With the global demand for livestock products expected to increase 30% by 2050 (FAO), sustainably feeding the world's growing population is one of the major challenges of our time.

Increasingly conscious consumers are shifting away from a diet that relies for protein mainly on animal-based foods, towards a flexitarian or vegan diet where animal-derived protein is partially or wholly replaced by alternative protein sources such as legumes. The majority of consumers, however, do not fully embrace animal-free alternatives: For example, only 12% of Australians are vegetarian or vegan. The mainstream consumers, even those seeking to reduce their meat consumption, still wish to enjoy the familiar textures, flavours, nutritional benefits, and cultural associations of meat. Tailoring plant-based foods to address these traditional consumer preferences is considered the key to unlocking massive growth in the consumption of animal-free foods globally.

Many plant-proteins, especially from legumes, are currently used for animal feed. Converting this feed to produce human food applications could be a sustainable solution to the agri-food sector and offers a tremendous innovation opportunity. This opportunity has seen a major increase of private and public investment in this area and fast development of technological solutions over the last decade.

This presentation will discuss benefits of alternative proteins and how material transformation via processing can be used to design food matrices and ingredients with good sensory attributes and proven health benefit to the end-consumer. Recent industry case studies and product applications, including plant-based meat substitutes of leading international and Australian companies, as well as future technologies, such as high moisture extrusion, 3D-printing, and precision fermentation of molecules for enhanced sensory experience, will be presented.

Special Session Plant proteins

Oral

PLANT-BASED MEAT AND FISH ANALOGUES BY TWIN SCREW EXTRUSION

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Plant-based products have evolved over the last couple of decades. Consumer expectations and awareness of the environmental impacts of meat and fish production have driven the development of alternatives for regular food

The protein fibration technology produces unique intermediate products, with fibrated internal structure similar to meat muscles. The strength of fibration can be adjusted by manipulating operating conditions: ingredients and formulation, equipment configuration. Texture profile of meat-like product can be further analyzed using instrumental texture analysis used in traditional meat products. The combination of complementary measurements such as tensile or shear strengths to measure firmness, elasticity, and/or chewiness allows describing the entire scope of texture of the fibrated protein by extrusion. This presentation will cover the latest developments in extrusion for meat and fish analogues.

Special Session Plant proteins

Oral

In-line rheometry and spectroscopy for controlled tailoring of textural and nutritional characteristics of HMEC-processed plant protein-based meat alternatives

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High moisture extrusion cooking (HMEC) is a technology to create fibrous structures from plant proteins resembling meat texture. Derived meat analogues provide similar textural mouthfeel to meat but are an alternative with only a fraction of the massive environmental impact of meat. During high moisture extrusion cooking plant protein containing materials are typically hydrated, sheared, heated (up to 170°C) and subsequently cooled and shaped in a long cooling die to avoid flash evaporation at the die exit. During such thermal and mechanical processing, proteins go through structural changes and reassemble in a shear and elongational flow-induced structure, stabilized by crosslink formation. To adjust textural and nutritional characteristics in a customized consumer-relevant range, in-line measuring methodologies for (a) the viscoelastic rheological protein melt characteristics and of (b) the product structure development, were designed and successfully adapted in extruder and cooling die sections of the HMEC process. The latter was run in traditional and novel micro-foaming modes in order to generate meat analogue products of controlled structure porosity and correlated texture and sensorially perceived tenderness.
For the first time in-line measured viscoelasticity characteristics like (a) the First and Second Normal Stress Differences (N1, N2) and (b) the shear viscosity h as a function of shear rate, temperature and water content were made in-line accessible and correlated with in-line measured spectroscopic (RAMAN, NIR) data as well as with mechanical characteristics (Young's Modulus, tensile- and cutting strength) of the resulting product structure. Based on derived Process-Structure-Functions (PSF) and Structure-Property Functions (SPF) optimization criteria were defined in order to feed a proposed novel HMEC process control framework for improving operational stability and reproducibility. Key technological aspects that unlock the next level of production autonomy were addressed by coupling a multilayer advanced control structure with the before-mentioned in-line techniques. The developed solution aims at optimizing process parameters while keeping the meat-like fibrillar structure formation and textural sensory characteristics at the desired level. The interplay of various parameters was considered by applying a model-based predictive approach that anticipates process future changes and derives optimal set-points. Extrusion results proved potential advantages and practical implementation of the approach.

Special Session Plant proteins

Oral

3D printing of meat analogues containing hydrocolloids, texturized pea protein and single cell protein: anisotropic structures by protein fibril alignment

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Objectives

The aims of this work were to a) formulate printing pastes suitable for extrusion-based 3D printing and to characterise their rheological properties, b) to study the direction-dependent (anisotropic) textural and microstructural properties of 3D printed, calcium-crosslinked meat analogues.

Methods

Meat analogue printing pastes were prepared with water (77.2 wt%), locust bean gum (LBG; 0.8 wt%) and/or sodium alginate (SA; 2-2.8 wt%), disintegrated texturized pea protein (TPP; 10-15 wt%) and single cell protein (SCP; 5-10 wt%). Viscoelastic properties were determined by stress sweep measurements. The printing toolpath was designed to print parallel strands, with interlayer staggering, using a 1.5mm nozzle. Prints were solidified by crosslinking with a calcium lactate solution (5 wt%). Textural properties were determined by cutting test in both longitudinal and transversal direction, and uniaxial compression testing. Microstructural properties of lyophilised samples were examined by X-ray microtomography.

Results

In all printing pastes, the storage modulus G' exceeded the loss modulus G'' and ranged between 4000-6000 Pa, indicating elastic-dominant, solid-like behaviour. Substituting portion of SA with LBG significantly increased G' (4049-4226 Pa to 5497-5909 Pa) and yield stress (24-39 Pa to 62 Pa), implying improved printing performance. All crosslinked meat analogues showed anisotropy as a significantly higher transversal than longitudinal cutting force. Presence of LBG significantly decreased cutting forces in both orientations compared to SA alone. Higher TPP:SCP ratio significantly decreased cutting forces and compression force in presence of LBG but was not significantly lower with SA alone. With SA alone, the anisotropy index AI (AI= $F_{Transversal}/F_{Longitudinal}$) was lower (1.3-1.4) compared to when LBG was present (1.7-1.9). Higher TPP:SCP ratio increased AI from 1.7 to 1.9 in presence of LBG and 1.3 to 1.4 with SA alone. Microstructural analysis and visual inspection revealed alignment of TPP fibrils along the path of the printing nozzle.

Conclusions

The created meat analogues are hydrocolloid-SCP gels reinforced with unidirectionally aligned TPP fibrils, determined by the toolpath. Anisotropy and meat-like appearance are mainly influenced by gel strength and aligned protein fibrils. Protein fibril alignment by 3D printing is a promising structuring technique for meat analogues mimicking whole-muscle meat cuts.

Special Session Thermal processing & optimization

Oral

Conventional and novel thermal processing techniques for sustainability and improved process design

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Thermal processing has been applied to provide safety and increase the shelf life of food products. While thermal food processing has been challenged with the use of innovative approaches like microwave and radio frequency applications for reducing energy requirements and increasing quality, conventional approaches still keep their significance as major pillars of the food industry. Additional concerns are food safety (the increase of food-borne outbreaks in the few decades are significant issues for process design) and sustainability. All of these coincide with the current challenges of environmentally friendly processing.
To satisfy all these concerns, mathematical modeling-based virtualization for process design and optimization is required. With the introduction of Industry 4.0, key components of machine learning, artificial intelligence, the internet of things, and others are expected to combine for sustainability and improved process design. While the computation model describes the process, additional components might be used for an efficient design and optimization.
Therefore, the objective of this study is to present computational examples in the view of food processing for comparisons between conventional and innovative approaches. A detailed research-based summary for process design and optimization for scaled-up industrial processes, based on physics-based mathematical modeling virtualization, will be introduced.
For this purpose, the following outline will be used:
- Conventional processes for thermal processing (canning and aseptic processing),
- Innovative approaches for thermal processing (focusing on microwave and radio frequency),
- Process design – optimization using mathematical modeling, and
- Comparisons of conventional and innovative processes (for thawing and pasteurization – sterilization).

With the challenges of the food industry for sustainability and improved process design, novel technologies are expected to play a more significant role. Computational modeling and virtualization are therefore presented as important approaches for designing efficient sustainable processes.

Special Session Thermal processing & optimization

Oral

Computer simulation to improve radio frequency heating uniformity of seeds by inserting horizontal aluminum and polypropylene (PP) plates in a rectangular PP container

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Uneven temperature distribution is a major barrier for applying radio frequency (RF) heating to replace traditional thermal treatments in foods or agricultural products processing, such as pasteurization of edible seeds. In this study, simulation models of watermelon seeds heated by RF energy were established using the commercial COMSOL software with or without inserting polypropylene (PP) or aluminum (AL) plate into a rectangular PP container and validated based on experimental results. The effect of inserting PP or AL plate at different horizontal positions on RF heating behavior of watermelon seeds was also analyzed by the validated simulation model. The results showed that inserting PP or AL plate caused different electric field distribution in the second layer of seeds. Meanwhile, when the insertion height increased from 5 to 35 mm, the volumetric RF heating uniformity index (0.033-0.118) for the second layer in seeds with inserting the AL plate was lower than that (0.127-0.165) of samples with inserting a PP plate. The optimal heating uniformity index could be obtained by inserting multiple AL plates with intervals of 10 mm among watermelon seeds. These findings can further be expanded to optimize the heating uniformity for developing an effective RF pasteurization and disinfestation protocol in foods or agricultural products without reducing their quality.

Special Session Thermal processing & optimization

Oral

Moderate Electric Field processing of food emulsions

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Moderate Electric Field (MEF) processing of foods includes direct application of electric fields up to the order of 10^3 V/cm, in a frequency range going from Hz to kHz. MEF application results in food heating and/or electroporation of cells included in the food matter. MEF heating is characterized by high rates of electrical energy converted into thermal energy, and it has been proposed as sustainable food processing technology. Foods eligible to MEF processing have electrical conductivity ranging higher than 1e-1 S/m. Of course, MEF processing could be not idoneous for food formulations containing fat (which is characterized by a very low electrical conductivity). This work presents a study on MEF processing of food emulsions, owning different formulations, for understanding the role of fat in determining the suitability of MEF heating for dressing sauces and heterogeneous food portions ready to eat. Electrical characterization of considered food formulations has been analyzed by using a custom MEF system, able to work between 40 Hz and 1200 Hz, up to 100 V/cm. Results show that, for dressing sauces, a range of fat/water/salt ratio exhists for maximizing the MEF efficiency.
At optimized conditions, MEF processed dressing sauces resulted also in better final color, as a prove of a lower thermal damage suffered by the tested samples.

Oral

Process Design and Optimization for Sustainable Thermal Heating: application to Ohmic Heating

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Many enabling technologies of Industry 4.0 contribute to the creation of so called Digital Twin, i.e. the virtual twin of a physical process that using mathematical models is able to describe the process, product or service in a precise way in order to carry out preliminary analysis and apply process control strategies. Digital Twin models often integrate software based on artificial intelligence, machine learning and data analytics using data collected from production facilities to create digital simulation models that update themselves in relation to the change in the parameters of the production processes. It is a self-learning mechanism, which makes use of data collected from various sources such as sensors that transmit operating conditions or supplemented by knowledge integrated by human resources.
In the food sector, the possibility of predicting, for example, the effects of heat treatments using different technologies according to the degree of food safety required in terms of abatement of microbial CFU is an extremely important objective.
In the present work a Digital Twin model will be presented for systems based on Ohmic heating in which the learning part of the system is also developed on the basis of mathematical models, through which the thermal effects of the electric field on the product are obtained using information on the cold points of the system coming from numerical simulations.
The information is then analyzed through artificial intelligence systems for the development of a reverse model able to indicate the electrical power required as a function of the maximum programmed operating temperatures, number of log reduction and electrical conductivity of the product.

Special Session Thermal processing & optimization

Oral

Ohmic heating for process improvement – Experimental and computer simulation analysis of recent applications in foods of systems working at high frequencies

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Recently, several emerging technologies in the thermal processing field of foods have been developed and are being progressively applied with the objective to produce safe and high-quality products. Although, ohmic heating (OH) is one of these technologies, there are few studies regarding applications of OH of food products at high frequencies. This work introduces original and recently published OH applications on foods at high frequencies, electrical conductivity data of the treated foods, and computer simulation models of the used systems to achieve uniform heating with the target to contribute with the growth of this technology in the food processing sector.
In particular, the ohmic cooking of rice, the pasteurization of eggs liquids in static, agitated, and continuous systems, and the heating process of meat and fish were evaluated. The electrical conductivities (EC) in the range of 50 Hz to 20 kHz were measured by a LCR meter and by monitoring the voltage and ampere in the temperature range of thawing and heating operations. The effect of temperature and frequency but also the composition of the foods, the direction of the muscle related to current flow, and the presence/absence of substances that might block the flow of the current such as membranes, fat layers, and skin were evaluated. COMSOL Multiphysics was used to construct 3D models to analyze the heat generation, temperature distribution uniformity, and to fine-tune processing parameters.
OH applications at high frequencies resulted faster and more uniform in temperature distribution than conventional OH process at 50 or 60 Hz, basically due to the higher EC values observed at higher frequencies. A fine-tune of the voltage resulted necessary for thawing applications to avoid runaway problems in some areas. Computer simulation of the processes helped to find hot/cold spots specially at higher electric field strength values in liquid applications, and to evaluate the effect of protein denaturation on the quality attribute changes in meat and fish samples. The data described herein could be of potential value in industrial applications for a better design of OH systems.

Special Session Thermal processing & optimization

Oral

MICROWAVE HEATING: EXPERIMENTAL AND NUMERICAL APPROACHES FOR PROCESS EFFICIENCY

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In the food industry, the use of electrical-based processes such as electromagnetic fields techniques applied to bio-based materials are expected to increase in the following decades facing the energy efficiency of such low carbon foot print processes. This work focuses on various experimental and modelling aspects dedicated to microwave heating applications at lab scale in the framework of research and development activities at GEPEA (France) since 2005. Basic concepts of heat transfer related to the microwave heating of food products are presented in order to understand the thermal behaviour of the material during the treatment. The process parameters and product properties are detailed with the different mechanisms responsible for the temperature rise under microwaves in the case of tempering, thawing, cooking and pasteurization applications.
The work also presents some highlights on the use of advanced multiphysics modelling techniques to predict the heating behaviour of a food product undergoing a microwave heating treatment. Major applications of microwave heating of food products at 2450 MHz and 915 MHz are presented by including both thermal and non-thermal effects on biological materials. Future prospects are also discussed concerning the development of modelling tools such as digital twins to improve the process-product interactions at microwave frequencies.

Special Session Thermal processing & optimization

Oral

A digital shadow to reveal the thermal effect of the drying tray during convective drying of carrot slices

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A key component of a physics-based digital product shadow approach is an adaptive computational model that allows incorporating all relevant physics on the required level of detail. Besides the representation of product specific features, the digital model must also adequately reflect influences of processing equipment, which makes it imperative to understand and model its thermal influence on the product to be dried. To that end, the presented work examines the thermal interaction between the drying produce (carrot slices) and the metal mesh tray it is placed on during a convective drying process. Possibilities to model the influence of this mesh tray on drying behavior are developed, investigated and discussed.
A validated hygrothermal continuous FEM model is applied to study the influence of a metal mesh tray with a bridge width of 2 mm and rectangular cutouts of 10 mm. Effects of heat transfer resistances as well as detachment due to product deformation are approached and their applicability is evaluated. A 2D-axisymetric model is applied. Connecting the digital model to the real world via sensor data – a digital shadow – is accomplished by incorporating the continuously measured infrared surface temperature as Dirichlet boundary conditions to the digital model.
Results show that drying behavior depends on the relative position of carrot slice and metal mesh due to different lengths of diffusion paths. The mesh contact influences the spatial thermal behavior of the material to be dried significantly and must therefore be considered. Detachment of the product from the metal mesh due to deformation plays an important role with respect to prediction accuracy of the digital shadow. It is shown that a sigmoid function is a good approximation to describe and model the detachment behavior.
In conclusion the drying tray, exemplifying general drying equipment design, plays a significant role in the development of a digital shadow/twin and must, therefore, be represented and verified in a suitable manner. Thus, increasing the prediction accuracy of the digital shadow and quantifying the effect of the drying tray.

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Special Session Thermal processing & optimization

Oral

Ohmic heating - design and performance of volumetric cooking, baking and preservation processes

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Ohmic heating is an alternative technology for thermal food processing based on the direct application of electrical current to food, which results in a rapid and volumetric heating of products. Benefits are derived from short heating times, improved heating uniformity as well as targeted and lower energy consumption. Application areas are the thermal preservation of high viscous and particulate foods, the heating or cooking of solid foods as well as the baking of dough. However, successful application requires the design of tailored processing conditions as well as the consideration of the product formulation. There is a need for further concepts to improve the treatment uniformity with special attention to tissue structure of raw materials and structural changes during the heating process, heat losses and cold spot location as well as the impact of process parameters related to treatment chamber design or the applied frequency. The presentation will point out key considerations concluded from case studies in ohmic baking, cooking of vegetables as well as preservation of high viscous foods. The results from the conducted studies reveal a high potential for commercial ohmic heating applications, particularly for time and energy reduction. In case of ohmic baking of gluten free bread, improved quality and functional properties could be shown while dramatically reducing the baking time. For the cooking of vegetables, main benefits were quantified with regard to more rapid and uniform heating and improved textural characteristics. In case of sterilization applications, reduced temperature gradients resulted in improved product quality and the mitigation of the formation of processing contaminants. It will be demonstrated, that a careful selection and control of the process parameters and the product formulation as well as a further improvement of the treatment uniformity are crucial in order to fully benefit from the volumetric heating principle.

Special Session Thermal processing & optimization

Oral

Computational multiphysics comparison: conventional vs ohmic heating assisted thermal sterilization validated at a semi-industrial scale

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Ohmic Heating (OH) is an emerging technology which is characterized by the volumetric heating of food products. OH preserves food delicately by maintaining the product quality and reducing the formation of neo contaminants caused by the thermal overload during processing. In former studies, OH characterization has been carried out on a lab-scale with precise operating conditions to avoid typical inhomogeneities that occur during large scale processing. However, process benefits also need to be shown at larger processing scales. Therefore, this study proposes the evaluation and comparison of a semi-industrial OH treatment to a conventional UHT thermal sterilization. For this purpose, carrot-based food matrices (juice representing low and puree high viscosity products) were inoculated with spores of Bacillus Subtilis and Geobacillus stearothermophilus and thermally treated at different temperature profiles with both a conventional UHT-unit and a colinear OH-chamber. To evaluate the sterilization efficiency and thermal load of the treatments, the F-Value was calculated for each temperature profile based on in-house determined inactivation kinetics of above-mentioned microorganisms for each food matrix. To determine and describe the treatment inhomogeneities a multiphysics computational fluid dynamics (CFD) model was developed for both conventional and OH thermal sterilization and validated through the comparison of temperature profiles and predicted inactivation rates. The implementation of CFD was a successful approach in obtaining accurate F-Values, which take into consideration the flow behavior and thermal inhomogeneities inside the equipment. The presence and influence of hotspots, which would have been impossible to characterize without the help of this computational approach, give a mechanistic explanation to the additional microbial inactivation observed after OH treatments. Moreover, this holistic approach allows the quantification of heat loss occurring through the usage of both processing technologies, which provides valuable information for the determination of energy efficiency. This study lays the groundwork for the optimization and design improvement of OH based thermal sterilization technologies, which require the implementation of multiphysics CFD models as the one developed for this study.

Special Session Thermal processing & optimization

Oral

Experimental study and modelling of a continuous ohmic heating system for starch matrices for 3D food printing application

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Ohmic heating (OH) involves the circulation of an electric current through an electrically conductive product, which will heat up by the Joule effect. The advantage of OH is its energy efficiency; it can reduce cooking times and gives a particular appearance to the product because of its ability to heat more uniformly. This work consists of developing a 3D printing nozzle using this technology applied to cake batter. The device consists of electrodes between which the batter flows. Heat exchangers, in which cold glycol water circulates in countercurrent, are used to cool the electrodes and facilitate the flow of the product, preventing clogging of the nozzle due to gelatinization. A numerical model was developed to help the design optimization. For validation purposes, numerical results have to be compared with experimental data. An experimental methodology was developed to have the temperature cartography at the nozzle outlet. The materials used are a cutting blade and a thermal camera. The blade quickly cuts the cooked product at the nozzle outlet to flatten the surface and the IR camera placed directly below takes a thermal image of the surface. The results show the expected heterogeneity of heating. The batter is hotter in the center of the product and colder at the edges due to the cooling of the electrodes and the specific design of the nozzle. Numerical results qualitatively agree with the experimental data.
Keywords: Ohmic heating, temperature profile, IR camera, 3D printing

Special Session Thermal processing & optimization

Oral

A novel reactor concept for ultra-short time / high temperature sterilization

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Abstract not avialble for technical reasons

Special Session Thermal processing & optimization

Oral

Electrostatic Spray Dryer: Alternative Drying Technology for ThermoSensitive Active Compounds

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In many industries, spray drying and freeze drying are mainly used to obtain a powder form in the final product. On one hand, spray-drying is a continuous process, scalable and widely used for different applications such as dairy products, active pharmaceutical compounds, oil encapsulation… However, high temperature is needed to reach moisture content expectations and leads to the degradation of heat-sensitive compounds. On the other hand, freeze-drying is a batch process using sublimation to preserve the active during drying andis mainly used for pharmaceutical products, microorganism, ... The main limits of this process are energy cost and time consumption. An alternative continuous technology, namely electrostatic spray drying, is emerging for drying sensitive products reducing the production cost to compare to freeze dryer. In this process, in the presence of the electrostatic field, there is a migration of solvent to the surface of the droplet which allows to have a complete drying at low temperatures [1,2]. Moreover, it was assumed that the second phase of drying: the failing rate period, is negligible allowing the active compounds to be in contact with a temperature equal or below of the outlet temperature (between 40 - 80°C).
In this work, this phenomenon is studied to quantify the benefits to avoid degradation of active compounds like probiotics, enzymes and DHA oil. Moreover, the life cycle of this new technology on industrial scale is also evaluated.

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Special Session Thermal processing & optimization

Oral

Design a microwave dryer with rotary drums, twelve magnetrons, and on-off sample temperature control: Simulations and experimental validation.

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Microwave technology is suitable for rapidly heating foods during domestic and industrial processing. However, this heating tends to be non-uniform, requiring strategies to minimize the hot spots that damage the food. This problem has been handled by suitable microwave cavity design, magnetrons arrangement, sample moving, and automatic temperature control by power manipulation. This study performed numerical simulations on the influence of the number and position of magnetrons on microwaves' distribution in a container with two rotating drums. Also, control strategies to improve heating uniformity were evaluated. Firstly, the numerical simulations using COMSOL Multiphysics® determined the electromagnetic field distribution inside an empty metallic container with octagonal sections (100 cm long and 60 cm wide), with twelve magnetrons (1.2 kW each) positioned on its walls. The experimental power dissipation in different water loads put inside the container in beakers validated the mathematical model based on the Maxwell equations (error of 15%). Besides, greater water masses inside the container and a higher number of active magnetrons resulted in higher equipment efficiency. The numerical results indicated that using six magnetrons is sufficient to obtain a uniform electric field. Moreover, the position of the magnetrons affected the distribution of the electromagnetic field. The control strategy was defined based on the best-operating conditions as determined by the numerical simulations. The controller was programmed to turn on or off as many magnetrons as necessary to control the sample temperature, measured with an infrared sensor. The temperature control strategy was tested using 8 kg (4kg per rotary drum) of expanded clay spheres, a porous and reusable material. The initial power was set as 7,2 kW (6 magnetrons on) to reach the sample temperature of 58 °C rapidly. Then, the power was reduced to 3,6 kW (3 magnetrons on) until 60 °C (set point). Afterward, the controller would turn off one, two, or all of the magnetrons to prevent the sample's temperature from increasing above 60°C. Therefore, sample moving, proper arrangement of magnetrons (number and position), and on-off temperature control guarantee the material's heating and drying, avoiding overheating.

Special Session Thermal processing & optimization

Oral

Evaluation of heat transfer from steam/air and water under the influence of ultrasound waves

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This study is aimed at evaluating the combined influence of ultrasound on the associated heat transfer from steam, steam/air and water media. Ultrasound has been effectively used with water, but has not been explore with steam or steam/air mixtures. Presence of air has been traditionally accepted to degrade the condensation heat transfer from steam. Heat transfer from steam, steam/air and water as influence by ultrasound variables were evaluated using high thermal conductivity materials (steel, aluminum) using regularly shaped metal transducers of as used successfully in earlier steam/air studies. Such high thermal conductivity materials are necessary (for maintaining low Biot number conditions) for accurate determination of surface heat transfer coefficients associated with steam. Results clearly showed differences in heat transfer rates with a significant reduction in heat transfer in the presence of air and the necessity to use ultrasound to remove the surface barrier for short term heatimng (5-15 seconds) vegetables for surfaces microbial decontamination.

Special Session Training & Digital

Oral

Food models diffusion for Knowledge transfer

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Models and scientific software are currently hardly shared among and (re-)used by stakeholders in the food domain, even though they are research products that can support the transfer of knowledge from academia to industry or to students. Scientific software generally incorporates models that capture fundamental domain in an explicit format, i.e. math equations, this makes them relevant knowledge transfer medium, under the condition that sufficient contextual information is provided along the software to favour the effective diffusion re-use by users.

Hence, what academia should do to support a better re-used of the scientific models ?
To provide an answer to this question, we reviewed selected approaches, best practices, hurdles and limitations regarding knowledge transfer via software and the mathematical models embedded in it, to provide points of reference for the food community. In this purpose, we focused on three aspects. First, the publication of digital objects on the web, which offers valorisation software as a scientific asset. Second, building transferrable software as a way to share knowledge through collaboration with experts and stakeholders in the domain of food science and technology. Third, developing food engineers' modelling skills through the use of food models and software in education and training.
By highlighting miscellaneous approaches regarding scientific software, this communication aims at promoting knowledge transfer between and within academia, industry and other stakeholders, and at opening prospects for synergistic efforts that will allow the food community to face the oncoming challenges.

This communication is based on works carried out for the COST Action CA15118 FoodMC and supported by European Cooperation in Science and Technology (https://www6.inrae.fr/foodmc).

Special Session Training & Digital

Oral

Design and Development of Take-home Laboratory Kits for Enhanced Food Science and Engineering Education

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Laboratory-based courses are a vital part of food engineering and related curriculum because they help students connect theories to applications and build both practical skills and conceptual knowledge. Studies show that laboratory activities enhance students' conceptual understanding and improve cognitive growth. However, many students struggle to gain access to laboratory facilities and physical experiments for a variety of reasons, including shrinking financial resources and scarcity of expensive laboratory equipment at many universities. Further, during the COVID-19 pandemic, many institutions were forced to switch to virtual classes and halt in-person laboratory activities. The development of remote laboratories offers a promising solution to support engineering education and provide equal access to all, including students taking online degree programs and students with physical disabilities that prevent them from accessing laboratory buildings. Remote laboratories employ low-cost, take-home kits that replicate laboratory equipment using inexpensive scale models. We designed and developed low-cost yet user-friendly take-home laboratory kits for measuring a variety of performance functionalities of food packaging materials, such as water vapor transmission rates of polymeric films and puncture resistance of certain thermoplastics and paper-based packaging materials. The take-home kits included in-house fabricated components and commercially available low cost sensors. We developed a set of instructions to guide users (students) to perform experiments, collect, and analyze experimental data. The laboratory handouts also included pre- and post-lab quizzes and questionnaire to assess the effectiveness of take-home kits on student learning. A separate set of instructions were developed for the instructors to implement the remote laboratory and to collect formative and summative assessment data. We are in the process of collecting experimental data to examine the effectiveness of the take-home laboratory kits in food processing and engineering courses from the participating institutions. Findings will be presented at the conference.

Special Session Training & Digital

Oral

Non-linear learning to design responsible food packaging

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The COVID-19 pandemic has forced us to intensify our connections, exchanges, and learning via WEB platforms. These solutions could help solve today's complex technological and environmental problems. The two consecutive ERASMUS+ projects, FitNESS for "Food packaging open courseware for higher education and staff of companies" and funded by the European Commission, were designed to imagine future responsible food packaging and supply chain. There is a certain honesty in recognizing that we may not have the right solution now and that the lack of material, chemical, and toxicological sciences in food engineering curricula has contributed to river littering, microplastics, chemical food contamination, and increased consumer exposure to endocrine disruptors... In the same vein, the sudden awareness of consumers and the encouragement to recycle and reuse materials create new emerging chemical and microbiological risks.

The FitNESS project does not take sides but details the different technical and scientific aspects of food packaging: concepts of food shelf life, materials, their chemistry, properties (barrier, mechanical, optical), hazards and risks, impacts and their assessment, safe and eco-responsible design techniques, industrialization... The corpus content (already 90 lectures, 6,000 slides, 60 videos, 20 case studies, books, and more) is continuously enriched by ten universities, research centers, and national reference laboratories across Europe.

The open-source platform is available as a client-side web application offering web conversion, deployment, mirroring, and local cloning. It works on any screen, online or offline, with/without presenter mode. A Google-like search engine understands more than 7,000 concepts to facilitate content reuse and non-linear learning. Web plugins offer online computations and interactive case studies to evaluate shelf-life and packaging compliance and optimize packaging. The presentation shows how independent syllabi and tests can be built and distributed. The AI-assisted content is the most promising feature, as it adapts the shown content based on the trainee's preferences and test results. As a result, chemists, materials scientists, food engineers, and retailers will experience seamlessly different content. Recent research results are distilled throughout the course to stimulate innovation and responsible decision-making. The platform could be used to teach and tackle other food engineering problems.

Special Session Training & Digital

Oral

Innovative Food Processing – a web-based decision making innovation toolbox for the food industry

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iNOBox, a four-year research project has developed a web-based innovation toolbox to help food industry make informed decisions on process innovation, overcome bottlenecks to market and ensure innovative products reach the consumers. The e-toolbox (www.innovativefoodprocessing.no) was built upon durable projects outputs and external data sources, enabling effective knowledge sharing of iNOBox outcomes.
With food security set high on the socio-political agenda, innovative food processing technologies can help to meet the demand of sustainable and affordable healthy diets for a growing and aging population. Safer and healthier foods resulting from innovative processing will improve the public health system through reduced prevalence of food allergy, diet-related diseases, food recalls and associated health/social costs.
iNOBox proposed five market-driven business solutions with broad transferability that integrate innovative processing technologies across relevant agri-food chains, towards better decision-making on sustainable process innovation and enhanced know-how/technology transfer.
Through cross-disciplinary research, iNOBox aimed at greatly advancing the current knowledge on the innovative technologies' cold plasma, pulsed electric fields, ultrasounds, UV-light, high-pressure processing, and microwaves. To ensure the successful implementation of innovative processes, food producers must be aware of their benefits (and how to communicate them to the consumers), their suitability for different products/applications, as well as scientific, technical and regulatory aspects.
We will in this lecture present the e-toolbox and the research behind it, and how it can support food industry end-users/manufacturers on scientific, technical, regulatory and sustainability matters, and support decision making in marketing strategies.
The iNOBOx project was founded by the research council of Norway and lead by Nofima, in collaboration with the Norwegian Veterinary Institute, NORSUS, University of Liverpool, Campden BRI, University of Zaragoza, TNO, and representants from innovative processing technology providers and the agri-food industry.

Special Session Training & Digital

Oral

DOCaMEx, a web-based educational and decision support tool that offers a new way of structuring knowledge based on concept maps and technological reasoning trees

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Faced with the increasing aging of the labour force in industry, the migration of processes to industry 4.0 along with recruitment difficulties in certain sectors, one of major challenges manufacturers face today is their capacity to build intelligent platforms for acquiring, storing and transferring their know-how and knowledge. Increasing automation and decision-making guided by data may also lead to the reduction of human labour in the production process, which may contribute to the disappearance of jobs, the reduction of expertise and the loss of know-how in manufacturing organizations. Weakened by this context, industry must also deal with increasingly restrictive standards, while struggling to rely on a growing quantity of generic knowledge and massive data, due to scientific and technological advances. Industrial sectors must turn to the acquisition of digital tools to structure their knowledge domain and then to develop and exploit the knowledge bases. Organising the transmission of knowledge and know-how within the company means enabling employees to acquire a methodology to transfer expertise in an effective and sustainable manner. DOCaMEx proposes a web based tool allowing stakeholders of any food industry sectors to collect, structure, share, remobilise the knowledge and know-how in a context of numerical and digital transition. It is composed of a reasoning engine, based on decision tree structures, that is capable of proposing action levers whose implementation can correct or maintain quality and an electronic knowledge book, based on a semantic network, capable of giving the user access to the entirety of the knowledge gathered from all sectors of the industry. Its aim is to:

- Avoid the loss of knowledge and know-how when people retire
- Formalize good practices and capitalize reusable knowledge to make transfer durable
- Encourage the sharing of expertise on a daily basis within the sectors
- Optimise and make reliable the handover between two or more people
- Ensure the preservation of knowledge and skills in the various sectors

It has the advantages:

- Usable by all stakeholders in all types of environments and with different levels of accessibility,
- Ergonomic interface,
- Integrated and manageable tool in the company,
- Semi-automatic construction and updating of the shared knowledge.

Special Session Training & Digital

Oral

A digital learning resource center to support the acquisition of knowledge and development of technical skills in innovative foods eco-design

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The ongoing Hybrid-Innovative-Learning-Lab (HILL) project involves about 20 higher education institutions and is funded by the French National Research Agency for ten years (2018-2028). The French experts involved (60) are mainly lecturers, researchers and educational engineers. Together, they seek to identify, structure, build and make accessible a digital educational resource center to support, in hybridization, the acquisition of knowledge and the development of technical skills in the field of eco-design of innovative food.
The digital learning resource center developed there covers six disciplinary processes : management of an eco-design project for an innovative food, development of strategic and operational marketing, design of a food, design of a packaging, design or adaptation of an industrial platform for food processing and management of industrial performance for sustainable production.
The different working groups have co-constructed both chronological and functional original representations of these processes, which include in their content 34 topics, 200 knowledge resources and a hundred skill resources.
The resources available on the digital learning resource center are structured in different forms such as methodological sheets, simulators with self-correction or quizzes to stimulate learning and validate the targeted skills. The digital learning resource center will be open to learners, lifelong learning and food companies, in face-to-face as well as distance learning. To illustrate this innovative training approach, the presentation of the learning path of food formulation and processing eco-design will be detailed.

Special Session Training & Digital

Oral

Digital Food Physics and Engineering: Learning Material for Everyone

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Objective
While quantitative, model-based understanding of food physics and its applications to computer-aided manufacturing is expanding rapidly, educational programs to prepare a future workforce well-versed in these topics have roadblocks such as unavailability of content at an appropriate level, missing pedagogical frameworks for effective learning, and the lack of sufficient learners at any one place to justify the effort. We address this by developing pedagogically rich, modularized, active learning-enabled, multistage content that is synthesized from recent research, and make it available freely on a Massive Open Online Course (MOOC) platform.

Methods
The modules are multi-level and connected for three groups of learners (academia and industry)—engineers with basic transport phenomena knowledge, researchers interested in modeling of complex processes, and food or related scientists without any mathematical background. The learning outcomes include the ability to: 1) Explain a food physics framework in terms of its basic building blocks that can describe many food processes, 2) Compare and contrast between simpler and more comprehensive physics frameworks for understanding food processes, 3) Apply a food physics framework to complex food processes for understanding and optimization.

Module contents move from the simplest to the most complex--from lumped to multiphase/ multicomponent transport in porous media with shrinkage/expansion. Mechanistic frameworks for food quality and safety complement the process framework. Applications come from different processes.

Results
Of the planned 30 modules, 15 have been completed and half of them have been used as part of a hybrid learning workshop at the Conference of Food Engineering ’22. The rest will be completed in the coming weeks. Feedback from the workshop shows the learners found the modules useful, engaging, providing the necessary background information, and having clarity of instructions.

Conclusions
Learner evaluations of the course’s initial offering showed that the MOOC-based approach with active learning should work for a range of backgrounds and abilities in an international setting, covering industry and academia. The modular approach will enable customization and inclusion in existing courses. The MOOC platform will provide scalability, assessment with instant feedback, and ease of evolution. All this should propel food physics/engineering education to a level appropriate for today.

Special Session Digital foods

Oral

Applications of Food Engineering in the Hurdle Technology: An Important Area Needs to be Progressed

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In reality any food product is produced based on hurdle technology. The applied hurdles are mainly identified based on trial and error or past experience. In the case of individual hurdle, theoretical approaches or generic guidelines are available in the literature. For examples, general guidelines or predictions of stability are available for the water activity, heat treatment (i.e. F-value) and pH hurdles. However, negligible progress has been done on the prediction of food stability when combined methods or hurdle technology are used. Even empirical correlations or generic guidelines are negligible when multi-hurdles are used. In this paper, the current status of the hurdle technology will be presented followed by identifying the future needs. First the reported metaphors for the hurdle technology will be presented. Second, the basic understanding of the hurdle effects to the microbes will be discussed with selected examples (e.g. homoeostasis, metabolic exhaust or auto-sterilization and stress reactions). These reactions to the microbes can guide us to apply hurdle technology in foods in an intelligent way. Finally, the potential of the food engineering approach, for examples multiple regression, probabilistic approach considering a boundary problem, multivariate analysis, data mining, machine learning, neural networks and fuzzy logic will be discussed to develop generic guidelines and prediction models. In this regard, available empirical correlations to determine food safety will be discussed when multi-hurdles are used. In the future, a food engineering approach could play an important role to achieve the progress of hurdle technology. Overall, this paper will present the complete overview of the hurdle technology including its past, present and future progresses.

ICEF14 INTERNATIONAL CONGRESS ON ENGINEERING AND FOOD | June 20-23, 2023 LA CITÉ DES CONGRÈS NANTES - FRANCE

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Oral

Flow, heat and mass transfer in coffee roasting

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Coffee in-cup flavour and aroma are generated by thermally driven chemical reactions during roasting, where the physicochemical transformation of coffee is governed by the applied time-temperature roasting profile. In the roaster, green coffee is transformed into roasted coffee, and signficant changes in physical and chemical properties occur during roasting.

Through simulation of the heat and mass transfer mechanisms that occur within the bean, and the batch of beans, the aim of this project is to gain better understanding of the engineering formulation of coffee roasting and build a digital twon for the process.

- a fundamental energy balance was used to develop a zero-dimensional simulation of coffee roasting time-temperature profiles at the batch scale and
- particle dynamic studies using Positron Emission Particle Tracking (PEPT) were used to understand the dynamic development of the bean-bed under different process conditions (Al-Shemmeri et al, 2021).

With these works as the basis, the aim of the current study was to combine heat transfer simulations (calibrated using real product and process measurements) and PEPT particle dynamic studies to

- construct a three-dimensional model for the thermal behaviour of a coffee bean within the roaster using accurate product geometry and properties,
- identify regional heat transfer coefficients corresponding to the bean-bed and in-flight regions and
- impose realistic bean surface boundary conditions.

By virtualising the roasting process, the heat transfer processes within the roaster can be identified and the temperature-time profile of the beans established. This creates a platform onto which the chemistry of flavour and colour can be modelled, and also establishes a method by which heat profile of the roaster can be considered as part of optimisation both of energy consumption and product quality.

Al-Shemmeri, M, Windows-Yule, CR, Lopez-Quiroga, E, Fryer, PJ. Coffee bean particle motion in a spouted bed roaster measured using Positron Emission Particle Tracking (PEPT), Journal of Food Engineering. 301, 110709, 2021

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Oral

A Digital Twin Approach to Improve Performance in Food Processing

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Digital Twin (DT) concept and its practical applications have been evolving rapidly due to advances in computer science and digitalisation in industries. The technology has gotten vast amount of attentions from both academia and companies. Targeted potentials and opportunities are acknowledged, however due to complexity of the industrial processes, define a virtual prototype of the physical unit operations may be still difficult or time consuming for real time simulation, optimisation, monitoring, controlling, and improving decision making. There is also a need for an infrastructure platform to join all parts of the specified DT framework.
In this article, we addressed an application of the DT in food industry, its challenges, and benefits. An in-house DT framework has been developed as a host for simulator, Programmable Logic Controller (PLC) and Human User Interface (HMI). Simulator includes semiempirical models for process components including mass, energy, and momentum conservations. All the models have been adapted to the Tetra Pak suppliers' specifications. A statistical or machine learning approach has been also developed to capture more complex phenomena such as Fouling development and removal.
The technology has targeted different areas of design and operation to improve the performance of the process line. Training our commissioning engineers reduces the delivery time, cost, and in-site tests. Customer's operators can get familiar and have hands-on practice with HMI before the production starts. The technology can provide valuable information regarding testing real time new conceptual design of the line, new products, trouble shooting of the line such as aseptic risk assessment and possible improvement of PLC/HMI codes.

Special Session Digital foods

Oral

Digital tools for efficient food manufacturing: For the community by the community

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Computer-aided engineering tools accelerate product and process design through reduced trial and error but such tools appropriate for the food industry have been slow to develop. Uniqueness, complexity, and variability of food materials and processes greatly contribute to this tool scarcity. Here we showcase two easy-to-use digital tools/platforms for efficient product and process design that can aid the most common product/process design issues, are freely available, and grow with community contributions.
The first of these tools is a food properties knowledge base where the user can easily and quickly estimate the properties of almost 10,000 food materials. In addition to obtaining quick data, such effortless visualization allows comparison of multiple materials for a property, multiple properties of the same material, and composition and temperature effects, leading to a materials science understanding in a discovery mode. The knowledge base is hosted using a relational database that stores property information either as algebraic formulas or a table of data points, and a convenient user interface to search, estimate, and visualize. The knowledge base has in-built crowdsourcing with quality monitoring so it can grow with community contributions.
The second resource is a repository of accurate and robust numerical models of important food processing operations, to be shared among the design, research, and education communities. Easy availability of these models through the repository, with their advantages of quick “what if” scenarios and a vastly improved mechanistic understanding, will propel the community faster toward simulation-based design of food products and processes. For example, one of the first entries in this repository, from our research group, is a dynamic deep learning framework-driven surrogate of a computationally expensive mechanistic model simulating convective drying. We expect this repository to be the go-to place for downloadable codes as well as online applications. The needed infrastructure that ensures quality is currently being finalized.
The two tools presented here cover a large area of food applications and cover industrial design, academic and industry research, and education. Built-in crowdsourcing ability, allowing growth with community contributions, should be a game changer in making computer-aided food engineering a reality.

Special Session Digital foods

Oral

Multiscale framework to simulate interactions in food systems from the chemical to the mechanical space: a step towards in-silico digestion

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Food's physicochemical and mechanical breakdown during oral processing and digestion is invariably complex. Many scales must be considered simultaneously: macroscale for hydrodynamics, mesoscale for structures, and microscale for thermodynamically- and composition-driven phenomena. The soft matter community has developed a wealth of Lagrangian simulation methods, but they fail to meet the time and length scales of food and oral processing. We propose to map the efficient smoothed particle hydrodynamics (SPH) framework onto more detailed ones capturing chemical details. The SPH methodology has several flavors adaptable to solid and liquid behaviors. They offer dramatic performance gains and predictions in the mechanical space of food (flow, macroscopic mixing, and fracturing). In the chemical and physicochemical spaces, acceptable predictions can be recovered only after proper parameterization, either from experiments or detailed simulations. This work explores a parameterization from Dissipative Particle Dynamics (DPD) to recover adhesion, lubrication, and non-ideal behavior in the chemical space.

The conditions for shadowing DPD simulations with SPH ones are shown for different strategies involving pure SPH particles, rigid and soft particles interacting only via Hertz contacts in a virtual viscosimeter (to measure stress at wall and shear viscosity), tribometer (to recover a pseudo Stribeck curve) and back-extruder (global texture assessment). The capacity of mapped SPH simulations to effectively study complex phenomena in foods is illustrated on solid and soft suspensions under shear and compression. The tunning of interactions between solid particles enables to reproduce flocculation and, in some ways, gelation. The mechanical behavior of simulated Pickering emulsions obtained with SPH-DPD framework is compared with experimental results. The framework is available as an open-source project for LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator, Sandia Laboratories, USA): https://github.com/ovitrac/Pizza3. Finally, the key steps to simulate the breakdown of insoluble food pieces during mastication and bolus transport in the digestive tract are detailed.

Special Session Digital foods

Oral

Development of an Image-based Food Recognition and Nutrient Profiling System

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Diets have high impact on nutrition-related illnesses and incidence of mortality among different population groups around the world. Dietary and nutritional status assessment currently rely on expensive, tedious and time-consuming monitoring procedures that are prone to flaws from data-gathering practices, human subjective attitude, and daily variations in a user's dietary intake. In this study, we propose an artificial intelligence-based dietary assessment system composed of an image-based food recognition network and a nutrient profiling method. Specifically, once the user captures the food image before consumption, the system identifies the food, retrieves the nutrient information from nutrient composition database, and then computes the nutrient profiling scores using the SAIN-LIM nutrient profiling model. Moreover, we provide a large-scale dataset of nutrient-labeled food images for dietary assessment. Experiments show that the proposed system performs effectively and efficiently on dietary assessment. The developed system can serve as a useful tool that enables users to self-administer and evaluate their food records as well as enables dietary researchers to track and analyze nutrition goals of clients and population groups.

Special Session Digital foods

Oral

Molecular Dynamics-like approaches and many-body forcefields as a universal strategy to simulate food from processing to deconstruction

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In the context of food, Molecular Dynamics (MD)-like methods assume that "food atoms" can be attached/detached, mixed, and react with other "food atoms" to build food structures, predict/visualize food fracturing, analyze the interactions between food and body fluids (saliva, bile salts), understand the critical steps of the contamination by food packaging substances... This lego-like interpretation of food science and engineering is poised to revolutionize the field by adapting coarse-grained models not designed to build systems at the irreducible atomistic scale but at meso to continuum scales.

The presentation shows the versatility of the approach to simulate complex structures and their evolutionary, transport, and reactivity properties in the presence of complex mixtures. The development of accurate forcefields is generally hampered by the need to encode the food's thermodynamic response and physical state in many interatomic potentials. Machine learning and many-body potentials are presented as a comprehensive and consistent alternative capable of providing dynamic simulations shadowing microscopic observations in near real-time. These new "food atom" potentials can be derived in two different ways: from numerical simulations conducted at a much lower scale (possibly with another coarse-grained but more detailed forcefield) or from displacement/deformation fields inferred from dynamic microscopic/macroscopic observations. It is shown that the first approach is preferable during digestion when the essential chemical information and micellar structures are not experimentally accessible and must be reconstructed from detailed simulations. The second approach works well on mechanical problems involving fluid-fluid (e.g., emulsions, foams) and solid-fluid (e.g., suspensions, gels) interactions but also for coupled flow-reaction problems, as exemplified in our study of thermooxidation during deep-frying. Various studies exemplify how our results can be transferred to various food contexts with reasonable computational power via our open-source project Pizza3 for LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator, Sandia Laboratories, USA). The project abstracts several food-specific tasks: converting experimental images into "food-atoms," setting food systems as a collection of "food-atoms" with desired shapes and distributions, and derivating new "food-atom" forcefields from existing ones. A static interpreter facilitates the implementation of programmatically defined complex moves and actions such as those met during food processing, oral processing, and digestion.

Special Session Digital foods

Oral

COMPARATIVE MEASUREMENT OF DIELECTRIC PROPERTIES OF FOOD POWDERS AT MICROWAVE FREQUENCIES BY OPEN-ENDED COAXIAL PROBE AND CAVITY PERTURBATION TECHNIQUE

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The dielectric properties of paprika, curry, corn starch and semi-skimmed milk, with moisture contents in the range of 5.63 to 7.74 % (dry basis), were determined by open-ended coaxial probe and cavity perturbation technique. The knowledge of these properties is essential to optimize the microwave heating process of such food powders. For the experiments with the open-ended coaxial probe, the system was coupled to a Vector Network Analyzer (VNA) with dedicated software. A custom-made device was built to improve contact between the coaxial probe and the surface of the tested materials. Then, a reflected signal (S11) was obtained by the VNA for frequencies in the 915–2450 MHz range, from which the dielectric constant and loss factor were deduced. Two resonant microwave cavities were designed using straight WR975 and WR340 waveguides, for the 915 and 2450 MHz frequencies, respectively. Quartz tubes were partially filled with products and placed inside the microwave applicators to account for small perturbation in resonant cavity. The S11 signal was measured by VNA and the shift in frequency was related to the dielectric constant, while the decrease in the quality factor (Q) was assigned to the loss factor. The results showed that the dielectric constant (?$_r$’) tend to increase with the decrease in frequency. The ?$_r$’ for paprika, measured at 2450 MHz by the coaxial probe and cavity perturbation technique, was of 1.06 ± 0.09 and 1.72 ± 0.00, respectively. At 915 MHz, the ?$_r$’obtained by coaxial probe was of 1.53 ± 0.09 and 1.96 ± 0.00 with cavity perturbation technique. The other products showed the same tendency for ?r’, and the loss factor (?$_r$’’) ranged from 0.02 to 0.36 for all powders. Open-ended coaxial probe requires close contact between the sample and the probe; therefore, this system was not fit for measuring the dielectric properties of the tested powders (air gaps between the probe and the samples). The cavity perturbation technique has been proven to be reliable for many foods, specially at low moisture contents, but requires a specific microwave applicator to be designed for each evaluated frequency.

Oral

Bringing knowledge in the technofunctionality of fruit and vegetables powders using a multiscale approach

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The current inability of most consumers to achieve the recommended daily intake of fruits and vegetables triggers food research toward the generation of improved fruit- and vegetable-based products and ingredients. Many types of fruit and vegetables are processed to increase their shelf-life (including drying and powdering), year-round availability, or to increase their value, which integrates structure-enabling and preservation techniques. It is now generally accepted that particle surface composition has a strong impact on the powder functional properties, such as reconstitution and flowability, as it constitutes the part of the powder particle that directly interacts with the environment. Consequently, monitoring only the bulk properties of a food powder during the production process is not enough to ensure good quality products.

In the powder form, the stability and the functionality of fruits and vegetables powders are maintained provided that the storage conditions are adequate. However, fruits and vegetables powders contain a high quantity of low molar mass sugars with low glass transition temperature (Tg). The direct consequence is that fruits and vegetables powders are highly hygroscopic and sticky at high temperatures but also at ambient temperature if the water content is not well mastered. This feature causes the powder adhesion through their surfaces leading to powder caking during storage, loss of solubility, which affects the quality of the final product.

The present project aims at understanding the process–structure–function relations to tailor the functional properties of fruits and vegetables powders. To this end, a multiscale approach is employed to investigate powder functional properties (flowability and reconstitutability) and particle surface properties (topography and roughness, adhesion and nanomechanics) by using atomic force microscopy (AFM). Even if process parameters define powder surface structure and functional properties, they can be impacted by environmental conditions (temperature, relative humidity) and the present project intends to reproduce them when performing AFM measurements with the aim to decipher mechanisms leading to powder surface modifications.

The overall objective of the present project is therefore to bring knowledge in the technofunctionality of food powders using a multiscale approach and enable the preservation of fruits and vegetables powders stability and quality.

Special Session Digital foods

Oral

In situ study of maltodextrins particle surface properties by environmental Atomic Force Microscopy

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Powders are widely used in the food industry, mainly thanks to their ease of use, handling, transport, or even for their extended storage properties. Powders techno-functionalities (such as reconstitution) are highly depending on powder surface, as it is the first part in contact with the ambient environment. Environmental conditions are known to highly impact powder properties, especially with the glass transition, which make powder undergoes from a glassy to a rubbery state, completely changing powder surface properties. For the first time on food powders, environmental Atomic Force Microscopy (AFM) was used to probe single particle surface properties in real time by variating relative humidity (RH) and temperature. Maltodextrins are widely used in the food industry, as excipients, thickener, encapsulating agent, or even for flavor enhancement. They are hydrolyzed products derived from starch and generally classified depending on their polymer length chain thanks to the DE value. In this work, low, intermediate, and high DE value maltodextrins value were used as a model matrix to study in real time and on a same particle the impact of an increase in RH and temperature. Thus, humidity ramps from 20 to 80% at constant temperatures of 20 and 50°C and temperature from 20 to 50°C at a constant RH of 20 or 80% were performed. Thanks to AFM, surface topography, roughness, but also Young modulus distribution evolutions at the particle surface were studied in real time. Thus, it was shown that glass transition and RH seem to drive the particle surface properties. Indeed, glass transition was always accompanied by a large global surface smoothing, whatever the DE value. This surface smoothing was also accompanied by a large decrease of the surface roughness with the increase of the humidity. Finally, particles in the glassy state were relatively hard with a high and heterogenous Young modulus distribution, whereas it slightly decreased with the increase of the RH. An increase of the RH made the particle become progressively softer, while crossing the glass transition temperature made the particle become way softer. These results were useful to show that glass transition significantly impacts particle surface properties.

Special Session Digital foods

Oral

Energy-efficient process for the manufacture of dairy powders using superconcentration and granulation

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Although spray-drying is the gold standard to manufacture dairy powders, it is an extremely energy intensive process. Previous studies showed that replacing spray-drying by superconcentration and granulation could lead to reduced energy footprint provided that critical parameters of the disruptive process were determined. The aim of this work was to identify the operating parameters controlling the process and to follow up the evolution of the physical properties of dairy products throughout superconcentration and their behaviour during granulation. In this way, relevant tools and techniques were developed at lab-scale and applied to dairy streams of different composition (in particular protein and lactose contents): skim milk, fat-filled milk, whey permeate and demineralized whey.
Results evidenced that a dry matter (DM) dependent highly cohesive (sticky) phase limited the extent of superconcentration, whereas the minimum dry powder recirculation for effective granulation was related to the end of this cohesive phase. The onset of cohesive phase was marked by a sharp rise in viscosity and yield stress. Besides, the composition of dairy products showed a great influence on the location of the cohesive phase: higher protein contents induced an earlier onset of this phase whereas higher lactose content delayed it. The cohesive phase started thus at about 62 % DM for skim milk and up to 80 % DM for whey permeate.
While higher protein contents negatively impacted the superconcentration step due to higher cohesiveness of superconcentrates, granulation of the paste was surprisingly more efficient using whey protein powder as a substrate. This result was associated to a higher water holding capacity of this type of powder. It opens then new perspectives for formulated products as different powders could be mixed with superconcentrates to prepare ingredients of targeted composition. The next steps of this work are to validate the outcomes from this lab-scale study at pilot-scale and go further in the optimization of the process and product properties.

Special Session Digital foods

Oral

Effect of the degree of polymerization of maltodextrins on the moisture sorption isotherms and the phase transitions

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Sorption isotherms show material's dependence of water activities on equilibrium moisture content at specified temperatures and pressures. Various factors such as nature of adsorbate and adsorbent, molecular weight, and composition might influence the behavior of isotherms. Model systems, like maltodextrins (MD), can be used to identify these factors and define properties for similar food structures like phase transition changes. These transitions can be identified when running isotherms, indicating modifications of material's structure and this can be analyzed through mathematical models.

This research aims to evaluate conventional (GAB, Peleg, BET, Oswin, Khün) as well as non-conventional models (Statistical Physics models) to describe water adsorption and desorption isotherms of MD with different degrees of polymerization, identifying phase transitions to characterize the modifications of MD's properties.

Commercial MD with different dextrose equivalents (DE) (1, 5, 10, 15, and 20) were used. Sorption isotherms were determined with a Vapor Sorption Analyzer (Aqualab) using the Dynamic Dewpoint method. Conventional models were tested to fit experimental data of the MD at 25°C. Phase transitions were identified using the second derivative method (SDM) and verified observing physical changes (color, volume contractions, agglomerations) in the samples stored at different levels of relative humidity (RH: 24, 33, 40, 57, 62, 70, and 80%) generated in sealed containers with NaOH solutions. Additionally, glass transition was analyzed using a differential thermal analyzer device (DTA).

GAB and Peleg models described the behavior in adsorption and desorption isotherms with R2 of 0.992 and 0.986. Monolayer moisture content (MMC) in GAB model decreased as DE increased (%d.b. MMC: DE1-6.52, DE5-5.45, DE10-4.9, DE15-4.67 and DE20-4.45). SDM showed several phase transitions between aw of 0.3 and 0.8. These transitions were corroborated with the DTA and physical changes on the samples stored at different RH. SDM results showed that samples with less degree of polymerization had transitions identified as maximum peaks between aw of 0.3 and 0.6, while MD with DE of 10,15, and 20 indicated transitions in aw ranging between 0.6 and 0.7.

This study elucidates the effect of MD type and content of sorption isotherms as well as transitions phases involved during the process.

Special Session

Poster

Impact of the air-liquid-material (ALM) interface on the formation and resistance of biofilms on different surfaces

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Biofilms are ubiquitous in nature and can form on both biotic and abiotic surfaces, posing a significant threat to human health and the economy. While the formation of biofilms on fully submerged surfaces has been extensively studied, the impact of the air-liquid-material (ALM) interface on partially submerged surfaces has only received limited attention. In particular, the role of the ALM interface in the formation and resistance of biofilms by foodborne pathogens and non-pathogenic bacteria has not been very well characterized.
In this study, we investigated the impact of four strains (Pseudomonas fluorescens [Pf1], Escherichia coli [Ec-SS2], Bacillus cereus [Bc-98/4] and B. subtilis [Bs-PY79]) and four surfaces (2R and 2B finish stainless steel, polypropylene [PP] and glass) on the A-L-M (air-liquid-material) biofilm formation and resistance to cleaning to standard clean-in-place (CIP) process. A great difference in biofilm amount was observed between the strains. For instance, Bs-PY79 failed to form biofilm, while other strains formed biofilm in the range of 4.7 and 7.4 log CFU cm^{-2}. For Ec-SS2 and Bc-98/4, PP surfaces held significantly less biofilm while no difference between materials in the case of Pf1 was observed. Upon subjecting biofilm to the CIP process (NaOH 0.5% at 60 °C), cultivable cells were only detected for Bc-98/4 biofilms (growth on agar), while biofilms were also still visible on coupons contaminated with Pf1. Furthermore, most residual biofilms after cleaning appeared orange by epifluorescence microscopy after staining with orange acridine suggesting the presence of many viable but non-culturable cells within the residual biofilms. Lastly, Bc-98/4 biofilms formed on stainless steel 2R were more resistant to cleaning than on PP and glass. These findings highlight the importance of considering the ALM interface in controlling biofilm formation and resistance, particularly in the food industry. Our results suggest that the susceptibility of surfaces to biofilm formation varies depending on the bacterial strain and surface material and that CIP processes may not be effective at completely removing biofilms from certain surfaces.

Special Session

Poster

The choice of allocation criteria influences the distribution of environmental impacts between co-products: example of dairy protein fractionation process

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Amongst human activities, food is a significant contributor to environmental impacts. The Life Cycle Assessment (LCA) method allows to quantify and analyze the environmental impacts throughout the production and transformation steps of a product. However, many agro-industrial transformations are multi-product systems and their impacts must be distributed among the different co-products. Several allocation methods exist, based on economic or physical criteria (mass, dry extract, protein content, lipid content, etc. of products) (Espagnol et al., 2017; Jolliet et al., 2017). The objective of this work is to study the influence of the allocation choice on the environmental impacts of co-products obtained from a dairy protein fractionation process (Gésan-Guiziou et al., 2019). The share of impacts allocated to the production of one of these proteins, α-lactalbumin, was calculated using several allocation methods and the most contributing factors to environmental impacts were identified. The results show that, regardless of the allocation methods, the contribution of targeted protein to the environmental impacts of the system is low compared to other co-products, due to its small quantity. For example, α-lactalbumin reaches a maximum of 2.8% of contribution to the greenhouse gas emissions for dry matter allocation. Dry matter or protein allocations attribute more impacts to α-lactalbumin than mass or economic allocations. The mass allocation penalizes the weightiest co-products (casein retentate, lactose). The economic allocation fluctuates with market prices and penalizes the cream and casein retentate, which generate the highest economic revenues. In the LCA of α-lactalbumin fractionation process, cleaning contributes from 3% to 22% of environmental impacts, depending on category. The other contributing factors are the energy of drying (from 1% to 35%) and that of membrane separations (from 0,5% to 36%). The allocation method is therefore a strategic decision and its choice must be considered in order to achieve the eco-design of products, processes and food chains.
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Special Session

Oral

Evaluation of the techno-functional properties of cricket (Acheta domesticus) flours produced from two body fractions.

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Abstract: This study aimed to determine differences in the techno-functional properties of powders from whole dried edible crickets (Acheta domesticus L.), the leg and antennae fraction, and the head and body fraction. Additionally, the effects of defatting on the techno-functional properties were evaluated. Samples were obtained by separating the legs and antennae with a Mesh 12 sieve. Defatted samples resulted from a petroleum ether extraction process. Then, the proximal characterization, water, and oil holding capacity, foaming activity, emulsion activity, and swelling capacity were evaluated. The dry-weight protein percentage remained unaffected in all powders (54.73%). However, the fat content of the head-body powder was 10% higher than the whole cricket powder, while the leg-antennae powder was 46% lower. Both leg-antennae and head-body fractions showed an increase in the water-holding capacity of whole cricket powder from 1.37 to 1.65 and 2.04 grams of water/ grams of sample, respectively. The water-oil emulsion capacity grew by 1.3 and 1.5 for the head-body and leg-antennae powders compared to the whole cricket powder. The swelling capacity increased from 122% for the whole cricket powder to 131 and 142% for the head-body and leg-antennae powder, respectively. In contrast, the head-body and leg-antennae powders' oil holding capacity was 25 and 19% lower than the 1.73 g water /g of sample value for the whole cricket powder. The head-body powder showed the highest oil-water emulsion capacity at 69.3%, while the leg-antennae powder had the lowest at 56.3%. The foaming capacity was highest for the whole cricket powder at 23.57%, followed by the leg-antennae and head-body powders with 20.33% and 18.33%, respectively. Defatting increased the evaluated functional properties in all powders except for the water emulsion activity of the defatted leg-antennae powder, which was reduced by 46% after defatting, and the foaming capacity of the defatted head-body powder, which decreased by 61%. Differences in the techno-functional properties from the evaluated cricket fractions could be due to protein/fat proportions changes. These results confirmed that protein-rich cricket powders could be obtained from different parts of crickets depending on the adequate functionality for the desired product.

Special Session

Poster

Optimized extraction of bioactive compounds from avocado oil by-products: a sustainable source of natural preservatives

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Vegetable oil production generates a large quantity of waste that is commonly improperly discarded. Industrial avocado oil wastes, such as peels and seeds, are characterized by a high amount of bioactive compounds, such as polyphenols and nutrients, with potential uses in the food and cosmetics industries. In order to limit the impact of these residues on the environment and to convert them into value-added materials, alternatives have been studied. However, further to the standard requirements for effective extraction of these valuable compounds, it is important to use a process that not only allows for environmentally friendly extraction techniques but also guarantees higher yields with minimal impact on the quality of the final product. Thus, the objective of this study was to optimize the extraction of bioactive compounds from the waste of industrial avocado oil (peels and seeds) using a central composite rotatable design (CCRD), solvents from a sustainable source, and assisted by ultrasound extraction. Three independent extraction parameters were optimized: ethanol concentration (%, X1), temperature (°C, X2), and solid-solvent ratio (g/mL, X3), with the dependent variable being the total phenolic content (YTPC). The results showed that ethanol concentration and the solid-solvent ratio were the most important variables. The temperature did not affect the extraction. The optimal conditions for extracting maximum TPC from avocado peels were 40% ethanol, 30 °C, and 0.225 g/mL of a solid-solvent ratio. For the seeds, the best conditions were 20% ethanol, 30 °C, and a solid-solvent ratio of 0.5 g/mL. The experimental results agreed with the predicted values, and the extracts obtained presented high antioxidant capacity. Hence, this optimized ultrasound-assisted method has been demonstrated to be very efficient in recovering bioactive compounds from avocado oil by-products, transforming these materials into value-added products with high antioxidant properties that may have different purposes. Acknowledgment: Coordination for the Improvement of Higher Education Personnel (CAPES), São Paulo Research Foundation (FAPESP), ESALQ Food, GETEP, and Paraíso Verde company kindly donated the samples. Project Sponsor: ESALQ/USP, CAPES, and FAPESP.

Special Session

Poster

Alginate as a potential polysaccharide for high oxygen barrier applications: influence of structure and composition

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Keywords: polysaccharides, alginate, oxygen barrier, films,

Alginate is a polysaccharide extracted from various species of brown seaweeds, which belong to the Phaeophyceae class. It is chemically a copolymer of (1 → 4) linked β-D-mannuronic acid (M) and α-L-guluronic acid (G) monomers. It is non-toxic and exhibits unique colloidal properties, such as thickening, suspending, stabilizing, gel-producing and film-forming. Moreover, when used in the form of films, it has a very high barrier to oxygen and a very good release profile of encapsulated molecules.
Depending on the origin, alginate chains can be characterized by disparate molecular weight and M/G distribution. This can potentially have a significant impact on the physicochemical properties targeted. Therefore, this study aimed to characterize the effect of molecular weight (MW) and guluronic/mannuronic acids ratio on the functional properties of four different alginate types, considering both the aqueous film-forming solutions (rheological and interfacial properties) and the self-standing films (mechanical and barrier properties). Surprisingly, no significant differences were detected among the tested alginate samples in terms of averaged tensile properties, namely Young modulus (≈ 1.9 GPa), elongation at break (≈ 8.4 %) and tensile strength (≈ 42.5 MPa), as well as oxygen and water vapor permeances (PO2 ≈ 7 ? 10-15 mol.m-2.s-1.Pa-1, and PH2O ≈ 1 ? 10-7 mol.m-2.s-1.Pa-1 at semi-dry condition and 25 °C). Furthermore, a structure-dependent effect was disclosed for what respect to the flow behavior. The high MW alginates showed greater values of apparent viscosity, together with a more pronounced shear-thinning feature, compared to their low molecular weight counterparts. Finally, alginate was found to exhibit a remarkable release behavior of small molecules in simulating gastrointestinal media. Based on the properties highlighted so far, alginate may stand as a promising candidate for food packaging and pharmaceutical applications which, in most cases, require a strong shielding capacity towards oxygen penetration to protect either the food or the sensitive agents (e.g., probiotics, bacteria, antioxidant, antimicrobials).

Special Session

Poster

DRIVING COMMITMENT TO A SUSTAINABLE FOOD SYSTEM: CONSUMER AND PRODUCER PERSPECTIVES

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Diet and nutrition are essential factors in promoting and maintaining good health throughout life. Their role as determinants of chronic non-communicable diseases is widely recognized. Additionally, the demand for food involves relevant environmental burdens that have to be taken into account on the way to achieving the UN Sustainable Development Goals (SDGs). The immediate need to build resilient food systems that support demand for water resources and greenhouse gases emissions is an immediate challenge. Food systems have the potential to sustain human health and support environmental sustainability. Nevertheless, they are a complex net of people and activities that comprise the production, processing, transport, and consumption of food. The foundation of food systems is agriculture and animal husbandry for food among to other uses. Current food systems, while significantly increasing food production, have had negative effects on the environment. Excessive use of agrochemicals and unsustainable use of water and energy have contributed to a multitude of global issues –water and air pollution, uncontrolled use of water and energy, loss of biodiversity, and risks to human health. In numerical terms, food systems are responsible for one third of global anthropogenic GHG emissions and 30% of the world´s total energy consumption. Therefore, the key challenge in the coming decades will be to produce enough safe and nutritious food for future populations without running out of resources or destroying Earth's ecosystems, i.e. without exhausting the biological and physical resources of the planet. That is, agri-food system needs to be climate sensitive and public health friendly. Sustainable and resilient agriculture is critical to tackling climate change whilst delivering food security and reducing dependence on finite resources such as fossil fuels. A drastic and sustainable transformation of conventional food systems is required to achieve the SDGs and the Paris Agreement. With these needs and challenges in mind, initiatives have been developed to lay the foundation for public food and nutrition at the national and global levels as well as focused on introducing changes on the cropping practices such as promoting legume-cereals rotations instead of conventional monoculture. All these issues will be presented and analysed in detail.

Special Session

Poster

Optimization of enzymatic treatments to optimize technological properties of apple bagasse

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Huge amounts of by-products are wasted during the production of apple juice. These by-products, rich in dietary fibre (DF) and bioactive compounds, could be used to obtain natural ingredients and incorporate them into foods for human consumption. However, their direct incorporation could cause undesirable changes, due to their high content of insoluble DF. Therefore, this study was aimed at optimizing the enzymatic treatment of apple bagasse to maximize the technological properties and the DF contents using response surface methodology (RSM).

Apple (Malus domestica cv Golden Delicious) bagasse was treated with Viscozyme (Novozymes®). RSM with a three-factor-three-level Central Composite Design (CCD) was used to evaluate the effect of time (1- 4 h), concentration (0.05 – 0.5 %), and temperature (40 – 60 °C) on water retention capacity (WRC), oil retention capacity (ORC), swelling capacity (SC), solubility, uronic acid concentration (UA) and neutral sugar concentration (NS).

The interaction between enzyme concentration and time had a significant impact ($p<0.05$) on WRC, ORC, and solubility. WRC and ORC decreased by 52 % and 77 %, respectively, when increasing treatment time and enzyme concentration. On the other hand, solubility was nearly two times higher than that of the untreated bagasse under such conditions. Higher UA (3798.10 + 644 ppm) and NS (16.9 + 2.8 mg/mL) concentrations were obtained with the application of Viscozyme (0.5 %) for 2.5 h at 50 °C. The increases in UA and NS contents and solubility suggest a higher content of soluble DF. The lack of fit of the model was not significant ($p>0.05$), indicating a good fitting to the experimental data.

The optimal conditions to achieve the maximum levels of WRC (14.8 g/g), ORC (5.2 g/g), SW (-3.2 mL/g), solubility (65.7 %), UA (1914.3 ppm), and NS (15.0 mg/mL) were: 3.29 h, 0.44 % enzyme and 46,65 °C. Thus, these predicted-values suggest that the use of Viscozyme could be a potential strategy to obtain natural ingredients with improved technological properties and high soluble DF content from vegetables by-products.

Special Session

Poster

Carbon Footprint of winter-wheat based cropping systems focused on food production

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This study aims to assess the global warming impact of winter-wheat cultivation under different rotation systems with potato, maize or oilseed rape over a six-year period in the region of Galicia, Spain, to identify the rotation system most favourable from a climate-change perspective, following a Consequential Life Cycle Assessment – (CLCA) approach. The results of this study are intended to guide farmers in their decision making regarding which cropping scenario they should choose in order to produce wheat grain for bread making with the lowest carbon footprint.

In this study, commercial and native varieties were considered for assessment in different crop-rotation systems. Three different crop companion strategies are assessed including potato and maize (traditional crops) and oilseed rape under different management regimes (conventional and organic, the latter only with the native variety). In the case of potato, the rotation system includes two consecutive years of wheat and one of potato. For rotations with maize and oilseed rape, wheat and the alternate crop are alternatively cultivated. The assessment is performed considering 1 kg of grain as functional unit.

The results showed that producing co-products and using animal manure as fertilizer does not necessarily reduce the environmental impact of the target product (i.e. wheat grain). The cultivation of native winter-wheat under organic management with maize is the best choice (-1.86 kgCO2eq·kg-1 grain). Nevertheless, the cultivation of the Galician variety under rotation with oilseed rape and conventional management is the worst choice (3.24 kgCO2eq·kg-1 grain). The reason behind these results is mainly the different delimitation of system boundaries, among other methodological factors. Organic scenarios report a climate-change profile that is penalized by the marginal electricity production. Moreover, these scenarios
report the lowest crop yields in comparison with conventional management, which directly involve highest impacts when the results are quantified per kg of grain.

Therefore, it should be borne in mind that the assumptions necessary for a CLCA have a major impact on the final results. In this regardm the identification of the marginal technology chosen for electricity production has a pronounced influence on the global warming impact and could led to opposing results.

Special Session

Poster

Trading in fad diets for sustainable diets: Comparison between the Paleo diet and the EAT-Lancet reference diet

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Food choice patterns are shifting globally - driven by dietary trends associated with controlling their weight – in ways that are adversaly affect human wellbeing and the environment. Among the set of popular diets, the Paleo diet has become increasingly popular over recent years, especially among young adults and athletes. Profound sustainable transformations in dietary patterns and food systems are needed to meet the Sustainable Development Goals and transcend Paris Agreement targets for cutting emissions. Efforts have been made by health authorities worlwide to develop dietary guidance and nutritional recommendations. In particular, the EAT-Lancet Commission developed a global planetary health diet, which is predominantly based on high-quality plant-based foods and low consumption levels of animal source foods. Therefore, the purpose of this research was to compare the global EAT-Lancet recommendations with dietary trends, such as the Paleo diet, in terms of carbon footprint and water footprint.

The Life Cycle Assessment methodology was followed to account for the evaluation of the carbon footprint and the water footprint. The daily dietary intake was chosen as the functional unit and the scope was bounded to the cradle-to-consumer phases along the life cycle: i) agricultural or industrial production stage, ii) distribution to wholesale and retaild and iii) distribution from retailers to households.

The carbon footprint value attributed to the Paleo diet was 5.4 kgCO2·person-1·day-1. On the other hand, the carbon footprint of the EAT-Lancet diet was approximately 2.6 times lower (2.1 kgCO2·person-1·day-1). The agricultural or industrial production stage represented the largest share of greenhouse gases emissions in both case studies, covering more than 90% of the emissions. On the other hand, our analysis also reported the average water footprint of the EAT Lancet diet (3057 L·person-1·day-1) and that of the Paleo diet (3499 L·person-1·day-1).

These findings suggest that human dietary trends such as the Paleo diet are harming human and planetary health. Promoting healthy diets within planetary boundaries such as the EAT-Lancet diet is key to achieving international health and environmental targets.

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Special Session

Poster

How COVID-19 reshaped environment-impacting consumer behaviour in Spain?

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HOW COVID-19 RESHAPED ENVIRONMENT-IMPACTING CONSUMER BEHAVIOUR IN SPAIN
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Abstract

Understanding dynamic and complex interactions between consumer eating behaviors, environmental change and the COVID-19 pandemic is fundamental to the achievement of Sustainable Development Goals and the Planetary Health Alliance. Spain has probably been one of the European countries where severe containment measures, such as social distancing, isolation and home confinement adopted by health authorities, has had a more severe impact on consumer behaviours. Within this framework, this study was carried out to assess the effects of COVID-19 health crisis on water-related and carbon-related implications of Spanish daily food consumption.
The life cycle assessment methodology was followed to account for the monitorization of the carbon footprint and the water footprint of the Spanish dietary pattern during and after COVID-19. The scope was bounded to the cradle-to-farm/factory gate. The functional unit selected was the average amount food purchased per person per day.
Results showed noticeable variations in the carbon footprint and water footprint associated to the Spanish dietary pattern throughout the years 2020 and 2021. The analysis revealed a major peak in both environmental indicators in March 2020-April 2020 due to higher household food consumption during lockdown months and restrictions of social distancing. Contrastingly, as the vaccination campaign advanced between December 2020 and August 2021, a downward trend in carbon and water footprint was observed.
These findings suggest that planetary health has been hampered due to the far-reaching impact of the COVID-19 pandemic. Recovery from COVID-19 requires efforts in the development of nutritional policy standards to protect the health of both people and planet.

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Special Session

Poster

Which factors influence resilience in food production and food value chains?: Results of an industry survey

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The survey aimed to gain an overview of current challenges and how to deal with them in terms of resilience in food supply chains. In this context resilience is defined as the ability of food production entities or food value chains to respond to, survive and learn from disturbances and crises. It can be differentiated between Engineering Resilience (Efficiency of Function) and Ecosystem Resilience (Existence of Function).

For the survey, an online questionnaire was developed and submitted to stakeholders of different food supply chains. The survey included questions on the business field of the companies, estimation of the influence of various causes of disturbances and measures to increase resilience. To structure the causes of disturbances, the respondents were able to select factors from the following categories: i) technical factors, ii) organisational factors, iii) human factors, iv) turbulences v) economic factors and vi) environmental factors.

84 companies mainly from primary food production and food processing and packaging participated in the survey. The factors that have a significant influence on resilience are outlined. Among others, organisational factors, such as the company's production capacity or the availability of raw materials were named as particularly influential by almost all. Furthermore, the results show that most companies estimate that they are not well prepared for disruptive events. It is made clear that there is a great need for action to improve resilience. Two-thirds of the producers and more than 80% of the processors affirmed that they wanted to make investments to improve resilience. Which topics are particularly in focus is presented.

In summary, the survey reveals factors that have an influence on the resilience of primary food production and food processing and packaging and what needs arise from it. To address the demands in a targeted manner subsequently, a concept for assessing resilience is presented. It supports the identification of weak points and the comparison of different system setups in terms of resilience.

Special Session

Poster

Lactic acid fermentation of Moringa leaf protein - selection of proteolytically active strains

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The demand for non-animal protein for food purposes is surging. Sustainable plant protein sources for high-quality protein alternatives for human nutrition are needed. Moringa oleifera is a fast-growing, drought-resistant shrub of tropical and sub-tropical regions with a high biomass/hectare ratio and a high protein content in the green leaves. The leaves can be further processed to obtain fractions that are rich in protein (30 -70 % dry matter base). However, the obtained protein fractions are largely insoluble which is a disadvantage for the application in various aqueous food systems. In the present study, the possibility to partially increase the protein solubility by lactic acid fermentations was investigated. Moringa leaf protein extract was fermented microaerobically under addition of glucose using selected species and strains of lactic acid bacteria. Proteolytic activity was assessed by measuring the glycene equivalents released through a controlled reaction with trinitrobenzene sulfonic acid (TNBS). The strains and combinations tested showed different potential in releasing glycene equivalents, indicating an increase in the solubility of the moringa proteins by fermentation. These experiments provide the foundation for further trials with targeted lactic acid fermentations with a proteolytic focus to taylor physicochemical and sensory attributes of protein powders derived from Moringa leaves.

Special Session

Poster

Effects of larval density and feeding rates on growth and waste reduction using Black Soldier Fly larvae

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Keywords: Black soldier fly, Waste management, density, feeding rate,

The organic solid waste degradation through black soldier fly larvae (Hermetia illucens L.) constitutes a promising alternative in waste management, given that it generates several products with added value. The development of this process and its application at an industrial scale implies knowledge of the load capacity itself. In this study, we investigated the effects of larval density (1, 2.5, and 5 larvae/cm^2) and feeding rate (75, 125, and 175 mg/larvae/day) on the bioconversion of organic solid waste. A fixed feed regime was applied at the start. The results showed that both variables significantly affected the bioconversion process. A daily feeding rate of 125 mg fruit/vegetable mix (1:1 ratio) per larva and a larval density of 2.5 larvae/cm^2 resulted in an optimum trade-off between material reduction efficiency and biomass production. Individual larval weight and total larval yield increased with higher feeding rates at all three larval densities. Therefore, we have demonstrated that larvae of the black soldier fly might convert large amounts of organic waste into protein-rich biomass, thereby contributing to sustainability.

Special Session

Poster

Measuring the environmental performance of a territorialized brewery sector

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The territorialisation of food chains is now a challenge in the context of food transition. A territorialised industry is made up of a set of actors, economic or otherwise, involved in the marketing of an agri-food product at all stages of the value chain, organised in such a way that some or all of the stages of the value chain: agricultural production - processing - distribution - consumption are located within a territorial perimeter claimed by these actors. The key to the success of the sector is coordination between upstream and downstream. It is based on the choice of location, on the size, on the planning and on the choice of technology. The environmental performance of territorialized chains is little addressed by scientific research.
Life cycle assessment has recently been able to show for food systems that increasing production yields reduces the environmental impacts of products by means of an economy of scale phenomenon Furthermore, it seems that the choice of geographical location of cultivation areas as well as the logistical choices of value chains strongly influence the environmental impacts of a given food system.
The objective of this study is to compare the organisational and technological choices that can be made along the supply chain and to study their environmental impacts, in the case of the territorialized brewery sector, a sector in full expansion. Life cycle assessment was used to compare several scenarios varying i) the choice of container, ii) the sizes of the structures, iii) the degree of locality of the chain, iv) organic or conventional production.
The study of the classical brewery chain scenario allows to identify the most influential processes on different environmental impact indicators and to look at the possible choices to reduce these impacts. In order to improve the environmental performance of a territorialized brewery sector, the first point to work on is the choice of container. Other solutions are more nuanced: producing organic beer, or producing in a brewery with large volumes could reduce some of the environmental impacts of the sector.

Special Session

Poster

PALM OIL AND BIOETHANOL FOR CO2 EMISSION DECREASING ON BIODIESEL PRODUCTION

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Soybean oil or beef tallow and methanol are the most common sources used on Brazilian biodiesel production. However, methanol, a fossil resource, is widely known by its toxicity, environmental impacts, and concern about future scarcity. Therefore, bioethanol can be an interesting alcoholic source to avoid methanol use, mainly due to market offer and renewable characteristic. Other oils could be also replaced as raw materials, to increase biodiesel production or avoid the lack of soybean oil in some regions. In this case, palm oil, can be an interesting alternative due to its high yields and low environmental impacts in Brazil, in relation to other country producers. To show the advantages of these substitutes in biodiesel production, environmental studies through life cycle assessment (LCA) are desirable. This work was aimed at evaluating the environmental impacts associated to the production of palm oil ethyl or methyl biodiesels, considering cultivation and production in Brazil compared to fossil diesel. 1 MJ of consumption was used as functional unit. Palm oil inventories from literature were entered into the SimaPro software, using the Ecoinvent3 database. The impacts categories “global warming potential” and “fossil resource scarcity” were calculated using attributional approach, mass allocation and Recipe Midpoint Hierarchist method. Results showed that, contrarily to expected, palm oil biodiesel produced by the methylic route presented lower CO2 eq emissions than ethyl palm biodiesel. The production process of ethyl palm biodiesel presented CO2 eq emission higher than diesel (40%) and methyl palm biodiesel (10%). However, its use in a diesel cycle engine can avoid CO2 emission, calculated at 3.4 times higher than its production emission, considering a factor of 2.76 kg CO2 eq. per liter. Additionally, the fossil resource scarcity impact for the methylic route is about 2 times higher than the ethylic route. Comparing to diesel, ethylic route showed a “fossil resource scarcity” 10 times lower. Ethyl palm biodiesel seems to be an attractive alternative fuel for preservation of fossil resources and to avoid global warming potential gas emissions, when compared to methyl biodiesel or diesel.

Special Session

Poster

The potential of electrotechnologies for enhancing the efficiency of precision fermentation processes

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In food and bio technology, proteins are increasingly produced in microbiological production systems, by means of fermentation. In conventional bioprocesses, downstream processing is usually initiated by cell disintegration, using high-pressure homogenization. This step is followed by extensive purification steps due to the resulting high loads of host cell impurities.
In order to reduce impurities of the resulting protein solutions, pulsed electric field (PEF) treatment and the resulting electroporation was investigated for permeabilization of cell membranes and the selective release of target proteins from *E. coli*. For this purpose, continuous electroporation was employed to selectively extract recombinant Protein A from the periplasm of *E. coli*. For this purpose, a specifically designed flow-through PEF treatment chamber was deployed, operated at 1.5 kg/h, using rectangular pulses of 3 ms at specific energy input levels between 10.3 and 241.9 kJ/kg. Energy input was controlled by variation of the electric field strength (28.4–44.8 kV/cm) and pulse repetition frequency (50–1000 Hz). The effects of the process parameters on cell viability, product release, and host cell protein (HCP), DNA, as well as endotoxin (ET) loads were investigated.
It was found that a maximum product release of 89 % was achieved with increasing energy input levels. Cell death also gradually increased, with a maximum inactivation of -0.9 log at 241.9 kJ/kg. The conditions resulting in high release efficiencies while keeping impurities low were electric field strengths ≤ 30 kV/cm and frequencies ≥ 825 Hz. In comparison with high-pressure homogenization, PEF treatment resulted in 40% less HCP load, 96% less DNA load, and 43% less ET load.
Therefore, PEF treatment can be an efficient alternative to the cell disintegration processes commonly used in downstream processing. Ultimately, PEF can contribute to design continuous or circular, more efficient bioprocesses for future applications in food and bio technology.

Special Session

Poster

Physicochemical properties of sesame cake protein isolates prepared by two different isolation techniques

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Sesame cake is the main by-product received from the cold press sesame oil extraction and is usually used as animal feed or fertilizer but, due to its high protein has the potential to be used as functional food ingredient. In this context, isoelectric precipitation (SCIP) and micellization (SCM) procedures were employed to obtain protein isolates from defatted sesame cake and compare their physicochemical properties. Protein purity was similar in both SCIP and SCM isolates (90.3±0.50% and 90.1±0.78%, respectively). Color of SCIP powders were darker (lower L* values) than SCM preparations probably due to the higher phenolics content of the former that are co-extracted upon alkaline extraction with this method. Protein solubility, examined in the range of pH=2.0-10.0, was higher for the SCM than SCIP isolate for pH<4.0 and pH>7.0, with both protein preparations exhibiting the lowest solubility at pH 5.0-6.0. Water retention and fat absorption capacity were higher for SCIP, which could be ascribed to protein conformational changes during protein isolation using this technique. On the other, hand, in vitro protein digestibility, which is an index to evaluate the nutritional quality of a food protein was found to be higher for SCM protein isolate than SCIP (58.30±6.1% and 33.40±3.6%, respectively). Foaming capacity and stability were dependent on pH and NaCl concentration in the aqueous phase. In general, SCM proteins exhibited higher foaming capacity than SCIP, whereas for both isolates, the foaming capacity increased with increasing NaCl concentration from 0-1.0 M. In general, the highest foaming capacity and stability was found at pH 2.0 and 10.0 for all examined NaCl concentrations. Concerning emulsifying capacity and stability, both isolates showed similar behavior, showing their lowest values at pH 6.0. Overall, both isolation protocols were proven efficient techniques for providing sesame protein isolates with promising functional and physicochemical properties. Comparative evaluation of these techniques indicates that the SCM isolate may be more suitable for industrial food applications and fulfilling consumers' nutritional requirements as it showed similar or in some cases improved functionalities than the SCIP preparation, such as higher solubility, foaming capacity, and protein digestibility.

Special Session

Poster

Optimization of infrared drying process of solid residues remained after essential oil distillation of salvia, melissa and satureja

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The utilization of solid plant residues (SPR) remaining after extraction of essential oil from aromatic plants represents an attractive solution that helps the essential oil industry to reduce waste and increase earnings. Utilization of SPR from these plants to obtain rich phenolic extracts (PE) presupposes a proper drying process. Infrared radiation (IR) heating is considered an attractive drying process since it allows uniform heating and high quality of the final product. The current research focuses on the optimization of the IR conditions for drying salvia, melissa and satureja solid residues (SR) obtained after the extraction of essential oil.
A response surface methodology (RSM) that consisted of a two-level full factorial central composite design (CCD) (α=1,414, 5 center points, total 13 runs) and was used to optimize drying time (X1, 20–60 min) and drying temperature (X2, 40–60°C) of IR process. The responses for each plant (salvia, melissa and satureja) were moisture content (%), total phenolic (TPC) and flavonoid content (TFC), DPPH (2,2-diphenyl-1-picrylhydrazyl), and ABTS (2'-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid) tests. The minimization of moisture content and maximization of the values of the other parameters was set as the goal of optimization. Moreover, the moisture content was constrained to be less than 10% in order to keep the SR safe from microbial/fungal contamination. The equations resulting from the analysis of response surface design showed to predict more than 76% of the variation. The optimized conditions were 11.7 min at 46.7°C for salvia, 11.7 min at 42.4°C for melissa and 11.7 min at 41.9°C for satureja SR giving overall desirability of 0.93, 0.87 and 0.78, respectively. Among the three plant SR, highest temperature was applied to salvia in order to achieve a decrease of the moisture to less than 10% without decreasing the content of phenolics and antioxidant potential followed by melissa and satureja. The results obtained revealed that optimization of the IR drying process assured safe storage, preserved phenolic content and at the same time ensured a low environmental impact due to rapid and cheap approach, suggesting perspective for its use in industrial scale.

Poster

Drying solid residues remained after essential oil distillation of rosemary with three different methods: An optimization study

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The essential oil distillation process of aromatic plants generates a huge amount of solid plant residues (SPR) that are considered a rich source of phenolics-antioxidants compounds. Valorization of these unutilized SPR to obtain phenolic extracts (PE) could address the sustainable development goals in the agro-industry sector. Proper drying of SPR represents a key to obtaining an extract rich in antioxidants. The current research focuses on the optimization of the rosemary SPR drying conditions of three heating processes: oven-drying heating (DH), microwave heating (MW) and infrared radiation (IR).
The response surface methodology (RSM) consisting of a two-level full factorial central composite design (CCD) (α=1,414, 5 center points, total 13 runs) was used to optimize drying time (X1, 30–120 min), drying temperature (X2, 40–60 °C) for DH process; drying time (X1, 20–60 min), drying temperature (X2, 40–60 °C), for IR process; drying time (X1, 1–4 min), drying power (X2, 400–1600 W), for MW process. The responses for each drying method were moisture content (%), total phenolic (TPC) and flavonoid content (TFC), DPPH (2,2-diphenyl-1-picrylhydrazyl), and ABTS (2'-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid) values. The minimization of moisture content and maximization of the values of the other parameters was set as the goal of optimization. Moreover, the moisture content was constrained to be less than 10% in order to keep the solid residue safe from microbial/fungal contamination.
The equations for each response obtained from the analysis of the response surface design showed values higher than 75% for R2 and higher than 0.70 for R2(adj). The optimized conditions for drying rosemary SPR were 96min at 33°C for DH, 28min at 36°C for IR and 1.7min at 400W for the MW process. These optimized conditions gave very high overall desirability: 0.78, 0.91 and 0.83 for DH, IR and MW, respectively. Among the three processes used, the MW decreased the moisture content to less than 10% in the shortest time. The results obtained revealed that if optimization is used there are advantages not only in terms of assuring safe storage of the rosemary solid by-product but also in preserving phenolic content and reducing energy consumption.

Special Session

Poster

The effect of montmorillonite chemical composition and extrusion process on a novel starch bio-nanocomposites for food packaging

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Chemical and physical modification of starch and/or addition of nanofillers, such as montmorillonite (MMT), have proved to be a promising approach to enhance starch performance. The main objective of this work was to obtain montmorillonite-filled starch bio-nanocomposites by extrusion process with improved performance for food packaging. Native cassava starch and modified by dry heating treatment were used as polymer matrix. Natural sodic montmorillonite was superficially modified using alkylpolyglucoside bio-surfactant (APG) to prepare organo-montmorillonite (OMMT). First, all components, including water and glycerol, were premixed in solid-state. Then, starch bio-nanocomposites were produced in two extrusion steps using a co-rotating twin-screw extruder at 100 rpm and temperature profile between 65 and 110 ºC. The extrusion process was also studied in order to compare the effect of each step on material properties. Structural properties of nanocomposites were accessed by X-ray diffraction. The reinforcement effect and material performance were evaluated by water resistance, opacity and barrier, thermo and mechanical properties. Dispersion of MMT resulted in bio-nanocomposites with intercalated structure. Nanocomposites from the first step featured a less-ordered structures. Nevertheless, the clay mineral was successfully modified by APG, increasing the interlayer space and compatibility with starch. As a result, OMMT was better dispersed and reached nanocomposites with partial exfoliated structure. Overall, starch properties were enhanced by addition of the nanofillers, mainly by OMMT. The main results revealed that water permeability and resistance were enhanced by 43 % and 32 %, respectively. Tensile strength and Young modulus of unfilled starch increased from 0.68 and 3.23 MPa to up to 2.31 and 14.24 MPa, respectively, by filling with OMMT. Oxygen permeability and opacity of the sheets were also greatly improved by nano-reinforcement. Furthermore, the melting peak of nano-structured starch increased by more than 15 °C when compared to starch, suggesting the formation of more well-organized crystalline structures. However, no significant difference was observed in thermal degradation behavior of the materials. As conclusion, the MMT modification by the bio-based surfactant is a good approach to enhance dispersion/interaction with starch matrix. The bio-nanocomposites developed in this work, with improved properties, is a feasible eco-sustainable alternative for food packaging applications.

Special Session

Poster

Hot trub from breweries as a source of phenolic compounds

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Beer is the alcoholic beverage most consumed in the world. With the high production volume, a high volume of solid waste that must be properly treated by the breweries is also generated, resulting in high production costs. On the other hand, several compounds such as proteins, phenolic, and fibers can be recovered from the solid residues. In this study, we investigated the extraction of phenolic compounds from the hot trub fraction, which is a residue from the boiling step that contains hops but was never assessed in the literature. The hot trub, from a West Coast IPA beer brewing, was collected in a local brewery. Then, the sample was centrifuged to separate the solid fraction from the liquid, and the solids' composition was analyzed. Ultrasound-assisted extraction (20 kHz, 6 minutes) with ethanol/water mixture was used as a green method, and a Box-Behnken design of experiment was used to identify the effects of the solid:liquid ratio (1:20, 2:20, and 3:20 m/v), ethanol:water ratio (10:90, 50:50, and 90:10) and temperature (30, 45, and 60 °C) on the total phenolic content (TFC) extracted. The total phenolic compounds concentration obtained in the ultrasound-assisted extraction varied from 0.015 to 2.488 mg GAE mL^{-1}. The three independent parameters of the design of experiment were considered statistically significant (linear effect) for the extraction, and their increase leads to the increase of the TFC extracted. The optimum condition for the extraction was assessed from the predicted model to be solid:liquid ratio 3:30, ethanol:water ratio 90:10, and 60 °C, resulting in a predicted TFC of 2.85 mg GAE mL^{-1}. Three runs were conducted in the optimized conditions, obtaining a TFC of 3.14 mg GAE mL^{-1}, which is within 10% error and indicates that the model represents well the behavior of the dependent variable. The ultrasound-assisted extraction was convenient to extract phenolic compounds from the hot trub obtained from breweries, but further analysis must be performed to identify the phenolic compounds obtained and future applications.

Special Session

Poster

Saving the planet with (the right amount of) packaging

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Keywords: plastic, sustainability, environmental impact, mathematical modelling, food loss,

There is increasing global focus on improving sustainability and environmental outcomes. Many industries are working to eliminate single use plastics throughout the supply chain to have packaging systems made of resuable, recyclable, or compostable materials. Many supply chain ackaging systems will need to be redesigned to meet these sustainability demands. Fresh produce storage often relies on the use of plastic packaging as a barrier for prevention of moisture loss (and subsequent product loss). Alternative strategies or materials that reduce plastic usage need to be considered across a range of sustainability metrics. The objective of this study is to develop a mathematical model framework that will allow future optimisation of packaging configurations to deliver quality kiwifruit while fulfilling sustainability demands. The model framework will be created through sub-models that predict internal conditions within the packaging system for any given combination of dimensions, material selection, and dynamic conditions in the supply chain. Fruit loss (as dictated by moisture loss) will be estimated using these sub-models. A Life Cycle Assessment model will quantify the resulting environmental impact of both the packaging and fruit loss. This will help in determining the best balance between the packaging format and materials, and their role in protecting the product. The framework can be used as a basis for continual development of sustainable packaging systems and supply chains that best meet specific market demands.

Keywords: Sustainability, plastics, supply chain, fruit loss, shelf-life

Special Session

Poster

Effect of the incorporation of apple pomace extract on the rheology of wheat flour doughs

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Adding value to food processing by-products is an important step towards economic, social and ecologically friendly progress. Apple pomace is the by-product from apple juice production, and includes the peels and the seeds of the fruit, that are rich in bioactive compounds. These compounds may have interesting technological and nutritional effects in products such as bread. However, it is important to evaluate the effect of their incorporation through an extract on the rheological properties of wheat flour doughs. Thus, the aim of this work was to evaluate whether the incorporation of apple pomace extract influences the performance of wheat flour. Wheat flour ideal for breadmaking was obtained from an industrial mill and the apple by-product from an apple juice processing factory. For the production of the apple pomace extract, a multi-step ultrasound?assisted extraction procedure using water and ethanol as solvents was carried out, followed by concentration in a rotary evaporator. The concentrated extract was then diluted in water at a 1:5 ratio (v/v). The farinographic and extensographic properties were evaluated using pure wheat flour as control, and 2.5, 5.0 and 7.5 % diluted extract replacing part of the water required for the control sample to reach ideal consistency for breadmaking (500 FU). The farinographic analyses indicated the behavior of a medium (water absorption) to strong flour (development time, stability and mixing tolerance index), with and without the addition of the extract, even though the increase in the mixing tolerance index (MTI) with extract incorporation suggested a possible weakening of the gluten network. The extensographic properties did not indicate variations with the extract after 45 minutes. However, after 90 minutes, the resistance to extension (R) of wheat flour alone was higher than that of the other samples, and the lowest was with 2.5 and 5.0% extract. Extensographic analysis again indicated the strength of the flour as medium-strong, with or without the addition of the extract. Therefore, the results indicate that apple pomace extract can be used in bread formulations, as incorporation up to 7.5% did not alter flour classification, but application trials are important.

Special Session

Poster

Dry ginger extracts obtained by coupled emergent technology

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Dry ginger extracts obtained by coupled emergent technology

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Ginger extract has high phenolic compounds such as sesquiterpenes, gingerols, and shogaols. The bioactivity of ginger extracts is correlated to total phenolics concentration and conversion of gingerols to shogaols, which generally occurs at high temperatures. Thus, when an extract rich in phenolics is requested, the process conditions of the drying and/or extraction can be adjusted, promoting the formation of shogaols from gingerols. In this study, two unconventional techniques were applied to obtain extracts with antioxidant activity: vacuum-microwave drying (VMD) (840 W and 100 mbar) associated with ethanolic ultrasound-assisted extraction (UAE) at 20 oC. Drying kinetics were studied. The extracts were characterized by total phenolic concentration and antioxidant activity. VMD had a processing time 36-fold lower than conventional oven drying (60 oC), which was resultant of its higher maximum drying rate (4.95 h-1) than oven drying (0.176 h-1). Between the drying models adjusted, Page and Midilli had a better fit, with R2 values ranging from 0.99439- 0.99689 and 0.99454-0.99961, respectively. Despite the reduction of global extraction yield by 60.9% compared to Soxhlet extraction, UAE was more selective, producing extracts richer in antioxidant activity (2100.7 mmol.Trolox/mL) and total phenolic compounds (387.6 mg.GAE/mL) than Sohxlet extraction (1055.6 and 295.9, respectively). Thus, the association of VMD with UAE was able to reduce the production time of ginger extracts while promoting more bioactive extracts than those obtained by conventional processes.

Special Session

Poster

Anthocyanins stabilization onto nanoclay: an evaluation of the physical-chemical and activity properties

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Anthocyanins stabilization onto nanoclay: an evaluation of the physical-chemical and activity properties

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In this work, jambolan (Syzygium cumini) extract content anthocyanin (ACNs) was stabilized by adsorption on montmorillonite (Mt) and characterized to the color, pH, crystalline and chemical properties. First of all, ACNs were extracted and quantified by absorbance before and after the stabilization. Total ACNs concentration in jabolan extract was 1.70 mg/g of fresh fruit weight. The pH of the extract was 2.5 and showed a red color typical of ACNs in acid solution (pH ≤ 3). The red color in the extracts was associated with the presence of ACNs predominantly in the form of flavylium cations. A good dispersion of the characteristic peaks of clay was observed, at 2θ?=?6,7°, 19.8, 20.8, 26.6, 36° and 60°, and which is attributed to T-O-T structure of montmorillonite and the SiO2. The spectrum of Mt showed bands attributed to Al-O-Si and Al-Al-OH bending, Si-O stretching, hydration and structural OH groups were observed. Specifically, in the region between 3627 and 3000 cm−1, the intensity of the absorption band is associated with the OH groups of the water molecules present in the clay samples. The pH increased after ACNs stabilization onto Mt, as well as the color change with pH and show good antioxidant activity.

Special Session

Poster

Investigating the impact of the extrusion process conditions and replacement of insect meal on pellet quality

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Recognizing the importance of exploring more sustainable protein sources to substitute fish meal in fish feed production, as the use of fish by-products is not able to sustain the fast-growing aquaculture industry. Extensive research has been conducted on various potential alternative protein sources like plant and insect protein which mostly focused on examining the effects on the nutritional profile of the feed and the fish´s performance with the inclusion of insect meal in the diet. However, only a few studies attempt to address how the insect meal affects the physical quality of the fish feed pellets.

The present study focused on the effects of extrusion process conditions on the physical quality of fish feed pellets at a different level of replacement with unprocessed black soldier fly larvae (BSFL). A three-factorial central composite design with regression analysis and response surface methodology was used. Eight response parameters were measured by varying four factors: screw speed, moisture, temperature, and the amount of added insect meal.

Two models were developed: 1) regression models describing the effects of all variables based on experimental design and 2) empirical models describing the impact of process conditions and composition. Both models describe well the impact on the physical quality parameters. The obtained results showed that water absorption and water stability increased with increasing insect meal level to a maximum value and then decrease at higher values. Samples containing insect meal showed lower hardness values and lower bulk density than pellets without insect meal, suggesting adequate expansion during extrusion. The lubricating effect of the insects was observed due to high-fat content that decreases the viscosity of the melt, which leads to lower heat generated by friction in the extrusion barrel. With established models, optimum replacement levels and process conditions were identified and tested. The results obtained show that BSFL is promising for fish feed improving some of the pellet properties with optimum process conditions.

Special Session

Poster

Co-production of fermentable sugars and added value compounds from chestnut husks using sequential hydrothermal treatments

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Chestnut is a traditional food that is specially used to produce marron glace and chestnut flour. Husks, that are removed during the peeling process constitute between 10-15% of the whole fruit's weight. The development of new strategies to recover valuable compounds from chestnut husks could contribute to an integral valorization of this by-product having into consideration a more sustainable circular economy approach. Therefore, this work aimed to assess the feasibility of sequential hydrothermal treatments to recover different fractions: a milder treatment to solubilize a phenolic and hemicellulose-rich fraction, and a harsher treatment followed by saccharification for the recovery of fermentable sugars from the cellulosic fraction.

Different sequences of one or two non-isothermal treatments (only heating and cooling ramps) ranging from 160ºC to 200ºC were applied. The different fractions were subjected to enzymatic hydrolysis using the enzymatic cocktail Cellic CTec2. Structural carbohydrates, phenolic composition and antioxidant activity were assessed using colorimetric and chromatographic methods.

Higher solubilization was observed in the sequential treatment of 180ºC followed by 200ºC, reaching a maximum of 42%. This totaled approximately 50g/L of carbohydrates being 15g/L monosaccharides. Glucose and xylose were the most abundant sugars with arabinose, glucuronic acid, and rhamnose in minor concentrations. For the fermentation inhibitors, higher acetic concentrations were present in the condition of 200°C (0.4g/L) whereas furfural and hydroxymethylfurfural were below 0.1g/L in all conditions. The oligosaccharide fraction was mostly composed of gluco-, xylo- and arabinooligosaccharides, reaching nearly 35g/L. In all treatments, saccharification yields surpassed 85%. Higher severities also resulted in high phenolic content with substantial antioxidant activity.

This work showed that the combination of hydrothermal treatments with enzymatic hydrolysis is a feasible approach to recovering several fractions with multiple applications. Specifically, phenolic compounds, oligosaccharides and fermentable sugars-rich-fractions may be obtained and used as ingredients in food formulation as technological agents with antioxidants and/or prebiotic properties. The final cellulosic fraction may be used as a substrate in fermentation processes to produce different commodities (e.g. bioethanol and bioplastics).

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Special Session

Poster

USE OF BARU (Dipteryx alata Vog.) BYPRODUCT TO OBTAIN TEXTURED VEGETABLE PROTEINS THROUGH THERMOPLASTIC EXTRUSION FOR APPLICATION IN PLANT-BASED PRODUCTS

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Baru (*Dipteryx alata* Vog.) is a fruit from the Brazilian Cerrado with an interesting nutritional and functional content. Currently, the demand for alternative proteins of plant origin has been growing, for use in the elaboration of several market products, submitted to different technologies, aiming at nutritional improvement, waste reduction, and even providing technological functionality. The extrusion process is one of the technologies used in food preparation, with special attention due to the versatility of the products obtained, the non-generation of waste in the process, and the high efficiency with low operating cost. However, the development of new extruded products with high protein content with an adequate profile of essential amino acids and rich in fibers is an opportunity to increase the availability of plant-based products. Therefore, this work aimed to produce textured vegetable proteins elaborated with baru byproduct for application in meat analogues. Three formulations (TA, TB and CT) were prepared mixing soy protein concentrate, vital gluten and defatted baru flour (TA 92:4:4 and TB 80:4:16, respectively). The control (CT) was elaborated only with soy protein concentrate and vital gluten (90:10). The textured products were obtained using a twin screw extruder, with four heating zones (60, 80, 135, 135ºC), constant rotation speed (300 rpm), and moisture content adjusted to 20%. The technological characterization of the textured proteins was carried out in triplicate, determining hydration, water absorption (WA) and water solubility (WS). The results showed that with the increase in the incorporation of baru flour there was an increase in the absorption of water. TB showed the highest water absorption followed by TA and CT. TB and CT exhibited greater fines release during hydration and did not present significant differences between them, while TA showed lower fines release when compared to the others. Such results show that the presence of fibers and other components in defatted baru flour can provide greater interaction with water due to fiber-water bonding. The results obtained show that the defatted baru flour, considered a byproduct, used at 4%, is a promising ingredient in the elaboration of textured proteins with potential application in meat analogues products.

Special Session

Poster

Chemical properties and fatty acid profile of macaw (Acrocomia aculeate) pulp oil obtained by aqueous enzymatic extraction

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Aqueous enzymatic extraction (AEE) of unexplored oil sources is an essential tool for food chain sustainability and bioeconomy. *Acrocomia aculeata*, also recognized as macaw palm, is an emergent oleaginous crop from South America with a high potential for the sustainable development of new food products. This study performed AEE with a commercial cellulase enzyme for oil recovery from macaw pulp. The extraction was performed in triplicate using 6.3% of the enzyme (regarding 60 g of pulp suspension: 30 g of pulp + 30 mL of buffer solution, 1:1 ratio) at 50 °C for 17 hours with constant agitation of 350 rpm. After the extraction, the reactive medium was centrifuged (13.500 rpm for 10 min), and the products were separated (free oil, cream emulsion, liquid, and solid fractions). The green process was evaluated by efficiency and oil quality (chemical and nutritional properties and fatty acid profile, FA). AEE and the control provided high free oil yields, 72.2% ± 3.5 and 65.7% ± 1.8, respectively. According to Codex Alimentarius (for traditional oils), low acidity (AEE: 1.01% ± 0.04 and control: 0.88 ± 0.04, oleic acid) was achieved for the extracted oil. In addition, the total carotenoids content and the iodine index value were 48.54 ± 6.39 μg g^{-1} (control: 93.30 ± 2.41 μg g^{-1}) and 85.08 ± 0.11 g I_2 100 g^{-1} (control: 84.74 ± 0.12 g I_2 100 g^{-1}), showing the presence of antioxidant compounds (carotenoids) and high unsaturated fatty acid content. The FA profile of macaw oil shows the predominance of unsaturated fatty acid in AEE (74.64% ± 1.24) and control (71.11% ± 0.14), with oleic acid (AEE: 72.35% ± 1.50 and control: 68.06% ± 0.15), the majoritarian compound. Furthermore, the oil presented excellent nutritional quality values in terms of atherogenicity and thrombogenicity indexes (AEE: 0.15 ± 0.01 and 0.33 ± 0.02 and control: 0.18 ± 0.01 and 0.39 ± 0.01 respectively), which could help to reduce cardiovascular risks. Thus, AEE is a green and sustainable approach for food industries to produce high-quality oil recovery from macaw pulp.

Special Session

Poster

Modelling of jet cleaning of processing plants – a data driven approach

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Most food processing plants are fitted with Cleaning-in-place (CIP) systems that use sprays/jets to clean vessels. The efficiency of these sprays/jets depends on a combination of processing parameters such as deposit thickness, nozzle diameter and sprays/jet flow rates. This work explores the suitability of using data-driven modelling techniques - i.e., Response Surface Modelling (RSM) and Machine Learning (ML) - to map and optimise such jet cleaning processes (RSM), as well as to predict their corresponding cleaning curves (ML).

A series of jet cleaning experiments of a viscoplastic deposit were designed to collect data and characterise the effect of (i) jet flow rate (ii) nozzle diameter and (iii) deposit thickness on cleaned areas (cm2) over time (up to 60 seconds) at both lab and pilot plant scale.

Results showed that for the system under study:
(i) surface response models can be used to map and optimise operating conditions for the jet- cleaning of a viscoplastic deposit, revealing those combinations of flow rate, nozzle size and deposit thickness that had potential to maximise cleaned area at the end of the cleaning process.
(ii) Artificial Neural Networks (ANN) can predict the dynamics of the cleaning process - this is cleaned areas at the observed times - from the test data set with accuracy (RMSE = 1.50). This method also provided a good of the cleaned areas values and cleaning curve trends at unseen times (time intervals not included in the training nor test sets).

Overall, this work presents a first approach to the use of data-driven techniques to model jet impinging CIP processes. Results revealed potential in using such approaches as the core of digital/virtual tools that help designing, monitoring and optimising hygienic processing conditions in the food industry.

Special Session

Poster

Correlation between pea protein fractionation and high moisture extrusion cooking behaviour.

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The food transition from conventional animal proteins consumption to plant-based or unconventional proteins (algae, insects and pulses) is an essential societal challenge to feed the world's growing population. Plant-based proteins, extracted from sources such as peas, soy, lupin or wheat, can be used as functional ingredients. Recently, they have been used in high moisture extrusion cooking (HMEC) to create meat analogues. However, process used for the extraction of those proteins (dry or wet process) can lead to a denaturation of the primary structure and thus can affects their technical and functional properties.
The present contribution aims to study the impact of two pea protein raw materials obtained by dry and wet processes on fibration: a pea protein concentrate, obtained by the dry fractionation (PPC), and a pea protein isolate, obtained by isoelectric precipitation (PPI). The objectives are (i) to obtain a satisfactory meat analogue fibration with pea proteins and (ii) to measure the impact on texture according to the fractionation process. The functional properties of the two fractions were characterized.
Particle size measurement as well as fluidisation and flowability index were carried out on PPC and PPI. Then, protein and water content, sorption capacity, conductivity and solubility at different pH were also studied. Structural state was further investigated by micro differential scanning calorimetry and electrophoresis. After this characterization, extrusion of formulation containing PPC or PPI were studied using a Rheomex PTW 16/40 OS MK2 Thermo Fisher corotative twin-screw pilot extruder. Extrudates texture were finally analysed by traction/compression as well as dynamic mechanical analysis. Fibers of these samples were then observed at macroscopic scale.
The results show that PPI proteins are denatured and have a high aggregation rate, with a lower solubility than PPC. The particle size of PPI is however more suitable than PPC for HMEC process.
The main conclusion of this study is that the fibration capacity of pea proteins is correlated to their fractionation process.

Special Session

Poster

IMPACT OF VEGETABLE FLOURS ON STRUCTURAL CHARACTERISTICS OF SUSTAINABLE BREAKFAST CEREALS OBTAINED BY EXTRUSION PROCESSING

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The use of vegetable flours in the formulation of processed foods is interesting, as they permit appeals for healthy, natural, and “clean label” products, also attending demands for sustainability and waste reduction. Among the technologies used in food preparation, we can highlight thermoplastic extrusion, due to advantages such as versatility in the products obtained, low production costs with high yield, and the non-generation of industrial waste, which allows the classification of this technology as environmentally friendly (“green processing”). Expanded breakfast cereals are among the products made by extrusion processing, and in recent years they have acquired a different profile due to the use of raw materials rich in nutrients such as fibers, bioactive compounds, minerals, proteins, and vitamins, improving their nutritional quality. Therefore, this work evaluated the use of vegetable flours from carrots (CF), spinach (SF) and beets (BF), rich in natural pigments (carotenoids, chlorophylls and betalains, respectively), obtained from vegetables with visual characteristics that are not attractive for retail marketing (too large, too small, crooked), as ingredients in a multi-colored breakfast cereal formulation, obtained by thermoplastic extrusion processing. For the preparation of the breakfast cereals, four tests were carried out, three were made by mixing broken rice (RB) with vegetable flours (CF, SF and BF) (90:10), and another using only broken rice (BR, as control). The cereals obtained (CFBC, SFBC, BFBC and BRBC) were evaluated regarding structural characteristics: expansion, density, alveoli formation (ImageJ software) and scanning electron microscopy (SEM). The incorporation of vegetable flours affected the physical structure of SFBC, CFBC and BFBC cereals, as evidenced by reduced expansion, increased density, greater surface porosity, formation of smaller and irregular alveoli when compared to BRBC. This is mainly due to the composition of vegetable flours, the low availability of starch and the presence of fibers and other components. However, the use of vegetable flours as ingredients in the preparation of expanded extruded breakfast cereals, in the proportion used in this work, proved to be promising for the development of sustainable, naturally colored breakfast cereals, that can be classified as “clean label”.

Special Session

Poster

Valorization of byproducts from meat and dairy industries through fermentation to obtain protein hydrolysates

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Background

Waste stream has become a global, ongoing problem in the 21st century, especially in the food industry. Valorization of food wastes by recovering their valuable nutrients and incorporating them into new products has been considered a more sustainable approach to overcome the world's growing human population and the massive production of food byproducts. However, due to the limitations of the protein extraction methods, a new, innovative bioprocessing technology needs to be developed to efficiently extract these components.

Objective
The objective of this study is to control protein hydrolysis with a fermentation procedure of waste streams from the meat and dairy industries.

Methods
Sodium-citrated whole blood from cattle and pre-sterilized acid whey from cottage cheese production were mixed in a ratio of 1:3 (v/v) with the addition of molasses as a carbohydrate source. Starter culture of *Lactobacillus rhamnosus* (OSU-PECh-69) was chosen to initiate the fermentation process due to its high proteolytic activity and the fermentation was carried out at 37?C for 5 days.

Results
Viability of *L. rhamnosus* was able to maintain at around 9 log CFU/ml while coliforms whose viable cell counts remained below the detection limit of 250 CFU/ml during the five-day fermentation period. In addition, the low acidity in the acid whey is favorable for the growth of lactic acid bacteria over other pathogens. The pH level continued to drop as the fermentation period went on which limited the growth of coliforms. A higher degree of hydrolysis was achieved in the fermentation mixture in treatment with the addition of *L. rhamnosus*. SDS-PAGE photos confirmed that large-molecule proteins were degraded into smaller molecules during fermentation with the blood-acid whey mixture inoculated with *L. rhamnosus*.

Conclusions
In this study, an alternative biotechnology of fermentation was able to overcome the ongoing problem of two nutrient-dense byproducts by valorizing the protein content through enzymatic hydrolysis. This work could be applied to the biological system in establishing usable and economically viable products as well as creating long-term sustainable processing solutions.

Special Session

Poster

Valorization of a protein fraction from the production of a meat pigment derived from porcine liver

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Nowadays, there is increasing interest in developing strategies for the efficient and sustainable use of animal by-products since they are a good source of valuable proteins. This work is framed in a project entitled "Obtaining zinc-protoporphyrin-based pigments and functional proteins from animal co-products". The general objective of the project was to obtain ingredients with technological and/or biological functionality from underutilized animal co-products with a low commercial value, such as porcine liver or blood. The pigment based on the formation of Zinc-protoporphyrin (ZnPP), in which the iron atom of the porphyrin ring has been replaced by a zinc atom, has recently been described in some meat products without added nitrites or nitrates.

The objective of the work was the physicochemical characterization and assessment of the functional properties of a protein fraction discarded in the production process of ZnPP pigment from pork liver, in order to reduce waste generation following a circular bioeconomy system. The effects of freeze-drying on the physicochemical characteristics of the protein fraction were determined.

The protein fraction showed poor techno-functional properties due to the extraction conditions, therefore, it could not be used as a techno-functional ingredient. However, due to its reddish-brown coloration and high protein N content, it could be used as a meat extender or to improve color of various meat products. Moreover, it might show some interesting biological functionalities such as antimicrobial, antioxidant and/or antihypertensive activities.

Thus, in this work, the in vitro antimicrobial activity of the freeze-dried product was investigated by means of a turbidimetric method using a Bioscreen automatic microbial growth monitoring system. The inhibitory growing capacity of a gram-positive (*Staphylococcus aureus*) and a gram-negative (*Escherichia coli*) bacteria at concentrations of 10^6 and 10^7 cfu/mL, of the fraction at different protein concentrations (0.75; 1.25; 2.5; 5; and 10%) was tested. The results showed that the peptides present in the freeze-dried samples had a slowing effect on the growth of both bacteria, starting at a protein concentration of 2.5%.

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Special Session

Poster

APPLICATION OF INNOVATIVE TECHNOLOGIES FOR THE RECYCLING OF AGRI-FOOD WASTE - H2020 AGRO2CIRCULAR AND AGROMATTER PROJECTS

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Keywords: Processing, Validation,

APPLICATION OF INNOVATIVE TECHNOLOGIES FOR THE RECYCLING OF AGRI-FOOD WASTE - H2020 AGRO2CIRCULAR AND AGROMATTER PROJECTS

In Europe, fruits and vegetables (F&V) are the higher contributor to the food wastes (>40%). These food wastes are an excellent source of natural bioactive compounds and are not being exploited.

Considering the changes in production models towards a circular economy to improve the sustainability of the food industry and the environmental problems involved in the management of its waste, there is currently a growing interest in the recovery of these agri-food by-products to obtain valuable compounds for food, cosmetic or pharmaceutical applications, among others.

Nevertheless, conventional methods of extracting bioactive compounds are inefficient (low yields and purity) and unsustainable.

OBJECTIVE
The objective of *Agro2Circular* is valorisation of agri-food waste through green extraction routes (innovative) to obtain bioactive compounds economically viable for industrial implementation, to produce new nutraceuticals, functional foods and cosmetics formulations. *Agromatter* aims to establish a network for the development of highly sustainable technical materials derived from by-products of the agri-food industry

METHODOLOGIES
For the valorisation of different agri-food waste (broccoli, cauliflower, apple, lemon, grape and artichoke), different extraction, purification and stabilisation routes have been optimised. Green solvents (aqueous solvents, natural deep eutectic point solvents (NADES), enzymatic solutions, subcritical water (SWE)) have been used for this purpose.

Assistive technologies to improve extraction yields (ultrasound (UAE) and microwave (MAE)) have also been evaluated.
Subsequently, purification (resins, membranes) and stabilisation (atomisation, freeze-drying, encapsulation) technologies have been used.

RESULTS
In general, enzymatic extraction has provided the best results in fibre extraction. However, of the agri-food waste studied, artichoke waste treated by ultrasound-assisted aqueous

extraction (UAE) showed the best results for the extraction of dietary fibre, improving enzymatic extraction by 12%. Broccoli waste has followed artichoke in terms of fibre extraction yields.

Lemon waste extracted by subcritical water extraction have provided the best results in the extraction of phenolic compounds, with hesperidin and limonin being the major compounds. SWE has improved the aqueous extraction by up to 340%. Secondly, artichoke residue extracts were the richest in phenolic compounds, with 1,5-O-dicaffeoylquinic acid (cynarine) and chlorogenic acid predominating.

Special Session

Poster

Characterization of naturally debittered olives (cv. Throumbolia) at different harvesting periods and maturity levels on the tree: Endophyte microbiota and physicochemical characteristics

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Objective:
Throumbolia olives are very nutritious (high phenolic content) with desirable sensorial characteristics, nevertheless, their picking is of high concern since their maturity level (consequently debittered taste) is not the same for all olives in a tree, not allowing for massive picking. This results in increased costs for picking and in mature olives falling on the ground and getting rotten really quickly, thus fostering disease and olive fruit flies. The aim of this study was to characterize the endophyte microbiota and the nutritional value of Throumbolia olive Greek variety.

Methods:
Throumbolia (Olea europaea var. media oblonga) olive fruits variety from Crete Island were collected at three different maturity levels on the basis of their skin color (green, purple and black) for two different harvesting periods. The olives were analyzed in terms of their microbiological characteristics by isolating the endophyte microbiota. Their physicochemical characteristics including color, texture, maturity index, total phenolic compounds, total anthocyanin content, total antioxidant activity, polyphenol oxidase activity and total pigments analysis were also evaluated.

Results:
The results indicated the presence of various fungi and yeasts, with Phoma oleae fungus being the dominant and responsible for the loss of bitterness while ripening on the tree. Simultaneously, the water content of the olives was reduced vs maturity level leading to shrinkage of the olives (»40% reduction from the maturity level 1-green olives to the maturity level 3-black and shrinked olives). Their exposure to air improved their color (darker colour) through oxidation process. All the above lead to Throumbolia olives of desired taste and texture and in high total phenolic compounds (7.14 mgCA/g), total anthocyanin content (57.18 mg/L) and antioxidant activity (2.46 mg Trolox/g) as affected by the ripening stage of the picked olives. The fungi found in the olives were isolated applying appropriate techniques.

Conclusions:
This study monitored all the microbiological and physicochemical characteristics alterations that took place during maturation and natural debittering of Throumbolia olives. The isolated fungi will in future be used in laboratory scale inoculation of picked unripen Throumbolia olives, targeting to controlled maturation, thus minimization of picking cost and rotten fruits.

Special Session

Poster

Valorization of industrial oat by-products through the design of high-value ingredients to be incorporated in food formulations

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Keywords: oat by-product, bleaching procedure, high protein, food waste,

Cereals are an important food source for a significant portion of the global population, and their processing generates substantial quantities of by-products. To promote sustainability and healthy lifestyles, industries are seeking innovative approaches to manage these by-products, which can serve as an economical source of diverse compounds. Oats, which are highly nutritious cereal grains consume worldwide, are particularly rich in soluble fiber, which can lower cholesterol levels, regulate blood sugar levels, and improve gut health. The present work aimed to transform an oat drink by-product into an added-value product that could be used in the formulation of different types of foods. After studying the oat by-product composition, it was subject to aqueous thermal hydrolysis and the resulting liquid and solid fractions were separated by centrifugation (10000 rpm, 10 min). The solid fraction was dried, milled to a particle size of 500 nm, and bleached. The decolored product was washed with distilled water and subsequently centrifuged at 8,000 rpm for 5 minutes. The color of the flour was evaluated through the use of a colorimeter reporting values of 4.76±0.89 for L*, 5.25±0.24 for a* and 11.61±0.32 for b*. The resulting flour had a high protein content of 31.0 ±2.1 g/100 DW, total dietary fiber 38.7±0.8 g/100 DW and β-glucans 8.54±0.16 g/100 DW. In conclusion, it was possible to obtain a bleached flour with high protein and soluble fiber concentrations, making its use a very promising ingredient for the formulation of different protein-enriched foods including pastry/bakery products, fruit preparations and/or yoghurts. Overall, this study demonstrates the potential for using by-products to create added-value products and promote sustainability in the food industry.

Special Session

Poster

Alginate and cuttlefish ink based caviar-like hydrogel beads as alternative to sturgeon caviar: Comparison of physicochemical properties

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Keywords: Processing, Product,

"Alginate and cuttlefish ink-based caviar-like hydrogel beads as alternative to sturgeon caviar: Comparison of physicochemical properties"

Caviar is obtained from the roe of sturgeon fish of the Acipenseridae family and has a delicacy with high nutritional. The sturgeon's maturation period for obtaining roe takes long time and cannot meet market and consumer demand in recent years. Modern food processing techniques such as alginate hydrogel spherification technique is an alternative to produce caviar alternatives.
In this study, caviar-like hydrogel beads as alternative to sturgeon fish caviar were produced from alginate hydrogel and cuttlefish ink using spherification technique. In order to develop sturgeon caviar alternative melanin-free ink (MFI) was extracted from processing waste of cuttlefish and added to alginate mix as antioxidant, colorant and fishy flavor. Physicochemical properties of caviar-like hydrogel beads produced from alginate by mixing MFI were compared with commercial caviar product. MFI ink contributed to taste, color and appearance of the caviar-like beads. In addition, caviar-like hydrogel beads produced in this study had long shelf life due to the antioxidant and antimicrobial properties of MFI.
Our results suggested that the caviar-like beads made from alginate and MFI could be an alternative for sturgeon caviar with its functional properties and lower cost. Besides, the production of caviar-like hydrogel beads from alginate and cuttlefish ink can provide an opportunity for the sustainability of sturgeon farming by reducing the original caviar production.

Special Session

Poster

Identifying critical food waste points in the millet supply chain and their potential to address food and nutrition security

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Keywords: millets, international year of millets, critical food waste points, food supply chain,

With the declaration of the International Year of Millets (IYM) 2023, an opportunity has opened up to raise awareness of, and direct policy attention to the nutritional and health benefits of millets and their suitability for cultivation under adverse and changing climatic conditions. Along with this, it also promotes sustainable production of millets while also highlighting their potential to create sustainable market opportunities for producers and consumers. According to the Communication Handbook and Toolkit for millets, the year aims to contribute to various UN 2030 Agenda for Sustainable Development, including, SDG 12 (Responsible consumption and production). And as per SDG 12.3, which states ‘By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, it is imperative to identify the drivers of food loss and food waste in the millet supply chain, so that we can control the loss and wastes that could be created with over-exploitation of millets in this scenario. The present work aims at identifying critical waste generation points in the supply chain and suggests possible interventions to reduce them or to utilize them as an alternative source of nutrition. The study would pave a way for the development of a package of best practices for possible use by potential supply chain actors for a much more resilient and sustainable supply chain for millets.

Special Session

Poster

Quality of fish balls from organic meagre side streams formulated with fish protein hydrolysate

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Demand in the global market is shifting toward higher value-added processed seafood with convenience and ease of preparation, and consumers are opting for products with high nutritional value that also satisfy sensory/hedonic attributes. Moreover, the sustainability of food systems has attracted the attention of the scientific community, which has focused its efforts on the reduction, management and use of food waste and by-products. Fish processing by-products are a source of different compounds with high commercial value, including collagen, gelatin, proteins, peptides, oil, lipids, chitin, vitamins, minerals, enzymes, pigments, and flavorings, which can be used as raw material as well as functional ingredients for the production of value-added products. The aim of this study was created a high valued add product based on meagre side streams with addition of Fish Protein Hydrolysate (FPH) from fish by-product. Fish balls were prepared from meagre (Argyrosomus regius) flesh obtained by mechanical separation of the side streams obtained after the filleting operation. FPH was added to fish balls at the concentrations of 0.5%, 1% and 1.5% in order to develop a product with high nutritional value and desired sensory properties. For this purpose, physicochemical and sensory tests were performed to investigate the quality of the final product. The results showed that the addition of FPH did not significantly affect the physicochemical parameters such as pH, water and content, color, tbars and texture. On the other side, flavor of the fish balls was significantly affected, with sweetness increasing with increasing FHP concentration. However, samples added with 1.5% FPH resulted as the best group for sensory analysis results. Overall, the present study showed that the addition of FPH from fish by-products can be a strategy for the production of high nutritional value products from meagre side streams without changing the quality of the final product.

Special Session

Poster

Recovery of nanostructured cellulose from agrifood residues

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The exploitation of by-products to recover biologically active compounds, such as polyphenols, antioxidants, proteins, dietary fibers, sugars, and flavors and exploit them for further applications has recently attracted increasing attention. The tomato processing industry represents an interesting case study for enhancing and integrating synergic solutions for waste management, considering that tomato is one of the most widely cultivated vegetable crops in Mediterranean countries. Nowadays, tomato pomace (TP), representing ~3-4% of the fresh processed tomatoes weight, is partially exploited for the extraction of lycopene, or as feedstock for anaerobic digestion to produce biogas. However, TP, consisting of peels, seeds, and fibrous residues, can also be exploited to recover cellulose because it is a good source of complex carbohydrates composing the lignocellulosic plant cell wall (approximately 65%dry basis of TP).

This work proposes a biorefinery approach for the utilization of TP by combining chemical hydrolysis and physical high-pressure homogenization (HPH) treatments, aiming to achieve the isolation of cellulose with tailored morphological properties, along with the valorization of the value-added compounds contained in the biomass. The cellulose extraction efficiency has been evaluated at different combination of chemical and physical processes, i.e. when the HPH treatment is applied directly on the raw material, after the acid hydrolysis and after alkaline hydrolysis. Moreover, the isolated cellulose is deconstructed to obtain cellulose nanoparticles. The size reduction enhances the properties of this polymer: the nanocellulose has low density, higher stiffness, higher tensile strength, transparency and a higher exposition of hydroxyl groups on the surface for functionalization. The chemical and structural features of cellulose isolated from TP with different combination of treatments were analyzed through light scattering for particle size distribution, optical and scanning electron microscopy, and FT-IR analysis. HPH pretreatment at different level not only promoted a slight increase in the yield of cellulose extraction but contributed to directly obtaining defibrillated cellulose particles, characterized by smaller irregular domains containing elongated needle-like fibers. Moreover, the selected mild chemical process produced side streams rich in bioactive molecules, evaluated in terms of total phenols and reducing activity. The liquors recovered from the hydrolysis of TP exhibited a high biological activity.

Special Session

Poster

Chitosan/alginate hydrogels containing phenolic-enriched extracts from saffron (Crocus sativus L.) flowers using Natural Deep Eutectic Solvents (NaDES) as green extraction media

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The current saffron production system is generating several hundreds of tons of tepal waste, since in order to obtain the spice only stigmas are used. Consequently, the valorization of saffron floral by-products by developing stable functional ingredients could lead to the environmental impact minimization. Thus, the main aim of this research was to evaluate the implementation and optimization of innovative green extraction processes from saffron floral by-products by using Natural Deep Eutectic Solvents (NaDES) and ultrasound-assisted extraction (UAE), to provide new information of an efficient environmental-friendly process which could be scaled up at an industrial level. Response surface methodology was used to optimize process parameters (Box-Behnken Experimental Design). To improve the stability of the optimal extracts, they were incorporated into chitosan/alginate hydrogels, studying their swelling behavior and water retention capacity and the total phenolic content (TPC) during the in vitro digestion. The results indicated that the optimal conditions for the extraction of bioactive compounds, at laboratory scale, were the employment of the NaDES Pro/Gly (1:2) at a NaDES/water ratio 90:10, 20 min extraction time and 180 W ultrasound irradiation. The results of the DPPH assay revealed the potent antioxidant activity of saffron floral by-products. The chitosan/alginate hydrogels incorporating the as-obtained NaDES extracts showed favorable properties whereas the TPC remained stable under intestinal conditions. Therefore, NaDES combined with UAE was an efficient technique to obtain high added-value compounds from saffron flowers, succeeding also the valorization of discarded waste by using green and low-cost strategies, contributing to the improvement of the sustainability of the saffron spice production and profitability of this industrial sector. Furthermore, these novel hydrogels showed favorable properties and were suitable matrices to incorporate bioactive extracts which may be used as promising candidates for various applications like food or cosmetic, among others.

Special Session

Poster

Portable beef-freshness detection platform based on colorimetric sensor array technology and bionic algorithms for total volatile basic nitrogen (TVB-N) determination

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Colorimetric sensor array (CSA) and bionic algorithms were integrated to form a facile platform for total volatile basic nitrogen (TVB-N) determination. First, a CSA containing twelve color-sensitive materials was prepared to obtain scent information of beef and generate scent fingerprints for visualization. Second, four bionic optimization algorithms, ant colony optimization (ACO), particle swarm optimization (PSO), simulated annealing (SA), and whale optimization algorithm (WOA), were used to extract the characteristic fingerprint variables from the CSA. Finally, the back-propagation neural network (BPNN) model combined with characteristic color components was constructed to determine the TVB-N during beef storage, with improved precision, robustness, and generalization performance. The results demonstrated that WOA had the best optimization performance, followed PSO, ACO, and SA. The BPNN model could realize high-precision quantitative determination of TVB-N during beef storage, as well as save resources for CSA preparation. Therefore, CSA in combination with an excellent bionic algorithm is expected to be a facile on-site sensing platform for monitoring food freshness.

Special Session

Poster

Alginate and cuttlefish ink based caviar-like hydrogel beads as alternative to sturgeon caviar: Comparison of physicochemical properties

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Caviar is obtained from the roe of sturgeon fish of the *Acipenseridae* family and has a delicacy with high nutritional. The sturgeon's maturation period for obtaining roe takes long time and cannot meet market and consumer demand in recent years. Modern food processing techniques such as alginate hydrogel spherification technique is an alternative to produce caviar alternatives.

In this study, caviar-like hydrogel beads as alternative to sturgeon fish caviar were produced from alginate hydrogel and cuttlefish ink using spherification technique. In order to develop sturgeon caviar alternative melanin-free ink (MFI) was extracted from processing waste of cuttlefish and added to alginate mix as antioxidant, colorant and fishy flavor. Physicochemical properties of caviar-like hydrogel beads produced from alginate by mixing MFI were compared with commercial caviar product. MFI ink contributed to taste, color and appearance of the caviar-like beads. In addition, caviar-like hydrogel beads produced in this study had long shelf life due to the antioxidant and antimicrobial properties of MFI.

Our results suggested that the caviar-like beads made from alginate and MFI could be an alternative for sturgeon caviar with its functional properties and lower cost. Besides, the production of caviar-like hydrogel beads from alginate and cuttlefish ink can provide an opportunity for the sustainability of sturgeon farming by reducing the original caviar production.

Special Session

Poster

Life Cycle Analysis of extraction techniques for recovery of valuable compounds from olive leaves

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In the framework of circular economy, agricultural by-products are utilized for the recovery of added-value compounds. Olive leaves account for 10% of total weight of olive trees and contain significant amounts of antioxidants compounds. The extraction technique is widely applied for the recovery of these functional compounds. Under the frame of sustainability, it is important to evaluate the environmental impact of such practices.

In this study Life Cycle Analysis (LCA) methodology was applied to evaluate the environmental performance and identify the environmental problems arising from the development of final functional extracts. Various extraction processes (conventional solid-liquid extraction and ultrasound-assisted extraction) were used for the valorization of olive leaves. The examined processes were either validated in pilot scale or in lab scale and extrapolated in higher scale using customised flowsheets and commercial modelling tools. LCA was implemented using commercial LCA software tools (openLCA with ecoinvent v2.2 and Agribalyse v3.0.1 databases). An ISO-standardized methodology (ISO 14040 and ISO 14044) for the evaluation of carbon, energy and water footprints taking into account critical factors in the life cycles of products and services was followed. The most relevant environmental aspects and parameters (e.g. GHG emissions, energy consumption, water depletion), with their influencing factors, were identified and compared. The LCA led to the estimation of overall eco-efficiency of the extracts, and guided the optimization of the extraction process, with the aim to maximize its eco-efficiency, by reducing the environmental impact, arising from the applied processes and materials used.

The solvent systems used play an important role on the extraction yield and different impact categories depending on their environmental footprint. The comparative life cycle assessment showed that ultrasound-assisted extraction was more sustainable method for the recovery of natural antioxidants.

Acknowledgement

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Special Session

Poster

Quinoa leaves, a sustainable source for plant-based new food ingredients

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Quinoa seeds has been highlighted as a good source of nutrients, among them, proteins, and their amino acid profile, for this reason has a constant growth market. Nevertheless, the global world population is increasing and the demand of proteins and protein-based products as well. For that, new proteins sources must be evaluated. In this regard, it has been indicated in a few reports, that quinoa leaves could be a sustainable alternative and can combat mega-droughts caused by global warming since it is a by-product of the seed harvest, which has not currently been valued. The objective of this research was to evaluate the parameters to obtain quinoa leaves concentrates, characterize it in terms of molecular weight, zeta potential, FT-IR, and evaluate some physicochemical and technological properties of interest, such as solubility, water retention capacity and emulsifying. The quinoa leaves used in this study was composed in a 32% (dry weight) by proteins, higher than 14% of proteins in seeds. There are different approaches to evaluate the protein extraction, starting with the leaves and subject to a pressing process to separate the fiber and thus obtain a high-protein juice. Another way is to dry the leaves, grind it and in this way obtain the concentrates. Among them, press the quinoa leaves allowed to obtain a higher extraction yield. Then, it was characterized and the molecular weight of proteins conforming the concentrate, and there was between 6 and 200 kDa and according to literature it was present the protein Rubisco (14 and 53 kDa). Zeta potential it was more positive and more negative (alkaline pH) as it moved away from the isoelectric point. With these results we are now determining technological properties in order to evaluate their use in food matrices as a plant-based food ingredient.

Special Session

Poster

Influence of the brewer’s spent grains (BSGs) concentration on the rheological properties of suspension added of alkaline hydrogen peroxide (AHP)

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During brewery, the generation and management of the by-products is still challenging. Brewer’s spent grains (BSGs) is the main residue produced in, with high potential to be converted into bioethanol and plant-based proteins, for example. However, adequate pre-treatments need to take place to reduce the biomass recalcitrance. Understanding how the rheological behavior of alkaline suspension of brewer’s spent grain is essential for the design of bioethanol production and extraction process. Thus, this work aimed at determining and modelling the rheological behavior of alkaline suspensions in different concentrations of BSGs. The dried raw material was firstly ground and sieved (Tyler mesh 100). Alkaline solution of alkaline hydrogen peroxide (PHA) was prepared at a concentration of 6% (g of PHA per 100g of dispersant). Different concentrations of BSGs were added to these solutions to obtain suspensions with final solids concentrations of 0, 2, 4, 6, 8 and 10% (g of BSG per 100 g of suspension). Steady-state flow were performed in triplicate in a AR-G2 rotational rheometer (TA Instruments, New Castle, USA) coupled with the SPC (Starch Pasting Cell) geometry and shear rate ranging from 1 to 265 s^{-1}. The rheological experiments were carried out at 278.13, 283.15, 293.15 and 303.15 K. The models of Newton, Bingham, Ostwald-de Waele and Herschel-Bulkley were fitted to the experimental data. The flow curves were better described by the Herschel-Bulkley model ($R^2 \geq 0.994$) with a behavior index (n) ranging from 0.81 to 1 and significant yield stress. Newtonian behavior was observed at concentrations up to 6% (g of BSG per 100 g of suspension) and shear-thinning properties at concentrations of 8 and 10%. Apparent viscosity increased with increasing solids concentration and decreasing temperature, with higher flow resistance at these conditions. An Arrhenius-type equation could be use satisfactorily to describe the effect of temperature ($R^2 \geq 0.992$). This, the concentration played an important role on the rheological behavior, being this information needed to design further conversion processes.

Special Session

Poster

Effect of temperature and alkaline hydrogen peroxide concentration on the rheological behavior of suspensions containing brewer's spent grains

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Brewer's spent grains (BSG) is a byproduct that represents 85% of the total waste generated by the brewing industry. Its sustainable use has been attributed toto the production of bioethanol, biogas, plant-based proteins, and other value-added products. In order to make the conversion processes of this raw material into value-added products easier, alkaline hydrogen peroxide (AHP) has been studied as a low pollutant chemical pre-treatment to reduce the recalcitrance of the lignocellulosic biomass. In this sense, the knowledge about the influence of AHP concentration on the rheological behavior of suspensions containing BSG was assessed to provide essential information for the design the unit operations associated to the conversion processes: e.g. mixing and pumping. For this, powdered samples of BSG at a concentration of 6% (g of BSG/100 g of suspension) were dispersed in aqueous suspensions containing different concentrations of AHP (0, 2, 4, 6, 8, and 10 g of AHP per 100 g of dispersant). The suspensions were subjected to steady-state flow using an AR-G2 rotational rheometer with the Starch Pasting Cell (SPC) geometry over a wide range of shear rates (1-265 s^{-1}), at temperatures of 288.15; 298.15, and 308.15K. In general, flow resistance increased with increasing AHP concentration and decreasing the assay temperature. The flow curves were well described by the Herschel-Bulkley model ($R_{adj}^2 \geq 0.99$), showing a shear-thinning behavior. The flow behavior index (n) ranged between 0.85 and 1, decreasing as the AHP concentration increased, but no temperature effect was noticeable. Under the conditions studied, the suspensions showed properties similar to liquids, which facilitate the mass transport and the access of enzymes when compared to high concentrate suspensions. The reported information can help predicting changes in the rheological behavior of BSG suspensions, in addition to the optimization of its conversion processes into value-added products.

Special Session

Poster

Impact of emulsification time on the stability of Pickering emulsions stabilized by modified starch nanoparticles

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The use of green techniques to modify native starches by heat moisture treatment (HMT) and by nanoprecipitation are attractive methods in the production of stabilizers for Pickering emulsions, aiming to produce highly stable emulsions and clean label products. The objective of this work was to evaluate the influence of emulsification time (3, 6 and 9 min) and concentration of starch nanoparticles (SNP) (0.8, 2.4, 3 and 4%) in the stability of Pickering emulsions using 20% oil phase. Starch was modified by heat-moisture method (20% moisture content, 140 ºC for 4h) and precipitated with ethanol to obtain nanoparticles. The physical stability of emulsions was investigated by cremation index for up to 14 days. The flow curves of emulsions were obtained with a rotational rheometer (TA Instruments) in the cone-plate configuration, at 25 °C in the range from 0 to 200 s-1. The cremation index showed that emulsions with 4% SNPs, regardless homogenization time and those produced with 3% of SNPs for times greater than 3 min were stable for up to 14 days. Microscopy was also performed to evaluate the behavior of the drops during storage All emulsions produced with lower SNP concentrations (0.8 and 2.4%) destabilized up to the 7th day of storage. The stable emulsions showed shear thinning behavior with $R2 \geq 0.995$ to Power Law model. The pseudoplasticity and consistency index increased as concentration of SNP increased and the homogenization time decreased. Micrographs showed that the emulsions with longer emulsification times (6 and 9 min) and higher concentration (4%) presented more heterogeneous droplets than those that were emulsified for only 3 min and formulated with lower concentrations of SNPs. Therefore, it can be concluded that SNPs produced by HMT and nanoprecipitation successfully stabilized Pickering emulsions against coalescence. These results show the potential of using only physical modifications to obtain nanoparticles that can produce stable emulsions by environmental friendly processes.

Special Session

Poster

Extraction and refining of BSF Larvae oil: the lipid profile shows the potential source of oleic acid, lauric acid and omega 6,

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OBJECTIVE
Extract and refine the oil from the BSF larvae and characterize the lipid profile of the oil by saponification and chromatography.

METHODS
BSF larvae were reared in a circular system for reusing organic waste (LetsFly, Brazil) and were killed by bleaching at 80 °C/90 seconds. The larvae were sanitized and subjected to 80 °C/5 minutes to then be processed (Arno Power Mix, Brazil) by the wet fractionation method. The liquid fraction obtained after grinding was submitted to crude oil extraction by centrifugation (Daiki 80-2B, Brazil). The extracted oil was then refined in two steps: 1) degumming with phosphoric acid (85%) to remove phospholipids/gums; 2) neutralization of the oil with sodium hydroxide. The refined oil was determined: the acidity index (Adolf Lutz Institute 471/IV), expressed in percent (%) of oleic acid per gram of dry larvae; the saponification index (Adolf Lutz Institute 479/IV), expressed in milligrams of KOH per gram of dry larvae; and the fatty acid profile by GC-MS (Shimadzu GC 2010, Japan).

RESULTS
The lipid profile showed a 4.76±0.23% acid value and 228.19±9.81 mg/g saponification value. The lipid profile by GC-MS showed a high concentration (68.27±0.40%) of saturated fatty acids, highlighting 42.06±2.19% of lauric acid (C12) and 14.08±0.69% of palmitic acid (C16). The lipid profile by GC-MS showed a moderate concentration (10.60±0.44%) of oleic acid (C18:1), considered an unsaturated fatty acid. Finally, the GC-MS profile also showed the refined oil with 8.33±0.41% of omega-6.

CONCLUSION
The methodology for extracting and refining the oil from the BSF Larva was satisfactory. The results of the lipid profile correlate similarity to the lipid profile of commercial coconut and palm fats. So, the refined Larva BSF oil has applicability in various industrial guidelines, including food, pharmaceutical, and cosmetics. The refined BSF Larvae oil shows a potential source of oleic acid, lauric acid and omega 6, both nutritional components beneficial to human health.

Special Session

Poster

By-product development from BSF Larvae shows satisfactory protein and lipid contents

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OBJECTIVE

By-product development from the BSF larvae and protein and lipid contents characterization in the powder product, the fresh larvae, and the fractions larvae post-fat extraction.

METHODS

The BSF larvae were reared in a circular system for reusing organic waste and the leftovers were directed to by-product development (LetsFly, Brazil). The larvae were killed by blanching at 80 °C/90 seconds. The larvae were sanitized and subjected to 40 °C/30 minutes to then be crushed (Arno Power Mix, Brazil). The liquid and solid fractions of the larvae were obtained after crushing. Fat was extracted from the liquid fraction by centrifugation (Daiki 80-2B, Brazil) and fat was extracted from the solid fraction by the press (Eurolume 456, Brazil). The post-fat extraction fractions were standardized with 5% stabilizer/emulsifier and were overrun in a planetary mixer (Mana BPM-05 AP, Brazil) until the stable foam was formed. The foam was dried at 80 °C/4 hours (Solab SL-102, Brazil) and was ground into powder (IKA A11, Brazil). Protein content by Kjeldahl method (AOAC 955.04) and lipid content by Soxhlet extraction method (AOAC 945.16) were determined in this powder product, in fresh larvae, and post-fat extraction fractions. Results are expressed as percent (%) protein/lipids per 100 grams of dry larvae and means were compared by ANOVA and Tukey test at a 5% significance level (Minitab, USA).

RESULTS

The powder product had 35% protein and 37% lipids. The fresh larvae had 37% protein and 41% lipids. The post-fat extraction liquid fraction had 32% protein and 45% lipids. The solid fraction after fat extraction had 59% protein and 9% lipids.

CONCLUSION

The powder product showed satisfactory protein and lipid contents to provide essential nutrients for human feed and it combats neophobia. The solid fraction post-fat extraction showed a higher percentage of protein and enables the development of new food sources of insect protein. The development of the by-product from the BSF larvae contributes to the biotechnological innovation of food inputs source of proteins and lipids.

Special Session

Poster

Monitoring the persistence of Listeria monocytogenes in dairy processing facilities by whole-Genome Sequencing technique

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One of the major safety concerns in the dairy processing facilities is Listeria monocytogenes that has been known to survive harsh environmental conditions and cause serious outbreaks of food born disease. There has been an interest to link between the bacterial contamination in food processing facilities and the genetic data of the species of concern. In the current research, dairy processing facilities were monitored by whole-genome sequencing (WGS) technique to comprehensively track Listeria contamination in different environments in the processing facility. The aim was to identify sources and link the environmental conditions to specific genes know for bacterial persistence in different conditions. The results showed that WGS method can accurately address the safety issues of dairy processing facilities.

Special Session

Poster

Energy consumption of a continuous flow ohmic heater with advanced process controls

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Ohmic Heating (OH) is a very energy-efficient form of heating compared to conventional methods such as conduction and convection. OH is a Moderate Electric Field (MEF) processing technique in which the applied electric field is ≤ 1kV/cm. The advantages of OH include rapid heating, reduced food processing times, bacterial inactivation, electroporation, and elimination of unwanted temperature peaks. Compared to other conventional methods of food processing, ohmic heating is over 95% energy efficient and high in energy saving. This paper describes the work to implement advanced real-time control on a continuous flow ohmic heater pilot plant. The comparison of the energy demands between conventional heating methods and different control methods implemented on the continuous flow ohmic heater is conducted. An analysis of the controller performance regarding energy consumption limit is also evaluated.

The application of classical to advanced model-based process controls including Proportional, Integral and Derivative (PID) control, Model Predictive Control (MPC) and adaptive model predictive control (AMPC) on the continuous flow ohmic heater pilot plant gives a template that can be replicated in the industry for efficient energy consumption. The implementation of these controllers is achieved on the programmable logic controller (PLC) hardware system using Open Platform Communications (OPC) and MATLAB. The energy consumption demands, and performance of each real-time controller are evaluated. The analysis of the energy demands of the developed controllers ensure sustainability and gives the option to select the most energy-efficient control methods while the ohmic heater is in operation. This research demonstrates the following:

- development of different real-time control methods to OH
- advantages of different control methods.
- the energy comparison of different control methods

From preliminary results, the energy demand while heating food products of different electrical conductivities, infeed temperatures and flowrates vary with the application of PID, MPC and AMPC techniques. The application of advanced process controls provides the best choice of control technique that ensures a high energy efficient heating process for different food products. This ensures the continuous flow ohmic heater consumes energy optimally and operates with a higher heating efficiency.

Special Session

Poster

Effects of roasting on the profile of bioactives and antioxidant activity of defatted-sesame meal

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Sesame seed is considered a good source of edible oil and it is widely used in bakery and confectionery products. Defatted-sesame meal (DSM), a by-product of the sesame oil industry, has attracted considerable interest in the food industry due to its strong antioxidant activity, although it is mainly used as a feed ingredient or as material to make compost. Roasting is a key step in the sesame oil industry that leads to changes in its organoleptic and quality characteristics. This study aimed to investigate the effect of roasting on the bioactive profile of water-soluble extracts from DSM.

White sesame seeds were roasted for 20 min in an electric oven at different temperatures (180, 200 and 220 °C). Sesame oils extracted from un-roasted and roasted seeds through cold-pressing machine and the respective DSMs were compared for their total phenolic content (TPC), phenolic profile (phenolic acids and lignans), tocopherols, as well as their antioxidant activity after ultrasonic extraction with 60% aqueous methanol for 1 min. The results showed that the TPC and antioxidant activity were significantly influenced by the roasting temperature, achieving maximum values after roasting at 220 °C for 20 min. However, although total sesame lignans' content was increased by roasting, there were no obvious differences among different temperatures applied. The main lignans identified and quantified in DSM samples were sesaminol triglucoside (SETG), sesaminol diglucoside (SEDG), sesamin and sesamol, while the major phenolic acids present were protocatechuic acid, 4-hydroxybenzoic acid, ferulic acid, p-coumaric acid, vanillic acid and caffeic acid. It was found that roasting decreased the contents of sesamol and phenolic acids, but increased that of sesamin. On the other hand, roasting had no impact on lignans glucosides contents. Moreover, a loss of tocopherols isomers has occurred after heat treatment. These results could be used industrially to obtain high quality sesame by-products which are considered a significant and abundant resource with numerous beneficial nutrients that positively affect human health. However, more work is needed to elucidate the factors that interfere with the formation and disintegration of bioactive compounds present in the sesame seeds during roasting.

Special Session

Poster

Wastewaters remaining after distillation of aromatic plants with three methods: Characterization as a source of phenolics for food and pharmaceutical use

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During the essential oil distillation process of aromatic plants is generated a large amount of two main by-products: the solid plant residual and the distillation wastewaters (DWWs), which represent a concern for the environment. Nowadays, the valorization of these by-products for use as natural antioxidants and functional ingredients in cosmetic, nutraceutical and food applications, is increased since they are considered economic and sustainable way for production of high added-value bioproducts. Despite growing interest in the valorization of solid biomass, studies on DWWs are scarce. Thus, the main focus of the current research was the chemical and antioxidant characterization of the DWWs produced by steam-, hydro- and microwave-assisted distillation of fresh aerial parts of melissa, spearmint, rosemary, sage and basil. The collected DWWs from the distillation of the abovementioned plants with the three different methods were lyophilized to obtain a dried form. Ultrasound-assisted extraction was employed as a sustainable and eco-compatible technology to extract phenolic compounds with a mixture of ethanol/water (60/40, v/v) in a very short time (1 min).
All the extracts obtained from DWWs by the three distillation methods, represented a promising source of total phenolic content (87–289 mg gallic acid/g extract), radical scavenging activity (138–350 mg trolox/g extract) and total flavonoid content (50–185 mg catechin/g extract). Melissa extract was the richest natural source of antioxidants, followed by spearmint extract, whereas no significant differences were obtained among the rest of the extracts. Recovery of phenolic extracts from DWWs was similar between the three distillation methods in the most of cases.
The qualitative analysis by HPLC-ESI-MS revealed that the extracts were rich in water-soluble phenolic compounds, mainly caffeic acid derivatives, with rosmarinic acid (RMA) being predominant (40–78 mg/g extract). It is noticed that DWWs from microwave-assistant distillation were the richest source of RMA along with the hydro-distillation, whereas steam-distillation yielded low RMA content in the most of species. In conclusion, DWWs from aromatic plants constitute a promising sustainable resource for the recovery of phenolic compounds and at the same time contribute to the reduction of the waste generated from the essential oil industry and environmental-related issues.

Special Session

Poster

Alternative extraction methods for the recovery of bioactive compounds from agro-food by-products: PEF and Microwave assisted extraction from olive pomace and tomato by-products

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The agri-food industry produces significant quantities of by-products that are underutilized or wasted, negatively impacting sustainability and environment. Olive and tomato processing by-products are rich in bioactive compounds (BACs), i.e. polyphenols, carotenoids, which can be used as ingredients for the development of high added-value products and their effective recovery and utilization has been the focus of research.
The extraction procedures play a critical role in the yield and functionality of the contained phytochemicals. Novel green extraction technologies improve BACs extraction yields at lower temperatures and short processing times, compared to the conventional methods. Pulsed electric fields (PEF) and Microwave-assisted extraction (MAE) can be used as alternative methods for the recovery of BACs from agro-food by-products, complying with environmental and economic requirements. This work aims to the evaluation of the efficiency of PEF and MAE extraction for increased recovery of BACs from olive and tomato pomace. Different Microwave (150-600 W) and PEF (1-5 kV/cm, 100-1500 pulses of 15 μs width) conditions, and solvent concentration at 30-50°C for 10-30 min were studied. The characterization and quantification of the extracts were carried out using HPLC analysis (total carotenoids, lycopene), Folin-Ciocalteu method (total phenolics) and DPPH assay (antioxidant activity).
Results showed that the use of PEF and MAE is efficient for recovering BACs, i.e. polyphenols and lycopene, from olive and tomato pomace, in significantly shorter time as compared to conventional extraction. The olive pomace extracts with highest antioxidant activity obtained with 40% methanol at 30°C. The optimum conditions regarding recovery yield for lycopene were microwave processing at 150 W for 10 min at 50°C. Similarly, PEF increased phenolic compounds recovery from olive pomace by up to 90%, and total carotenoids by up to 50% from tomato wastes compared to untreated samples.
MAE and PEF can be considered fast, effective, and environmentally friendly techniques for extracting BACs from olive and tomato pomace, offering important advantages in terms of yield, selectivity, extraction times and quality.
The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 03591).

Special Session

Poster

Effect of storage conditions on quality of aquatic biomass powders from fish side-streams enriched with natural antioxidants

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Globally, one third of the food produced for human consumption is wasted every year. Aquaculture and fisheries contribute 35% of total food losses and waste. Marine biomasses are rich in bioactive compounds that can be used as value-added ingredients in different applications. Due to their high content of unsaturated fatty acids, highly susceptible to oxidation, the effectiveness of incorporation of alternative antioxidants from natural sources as to ensure their quality and stability has been the focus of research.
Salmon filleting residues were used for the preparation of fish-based lyophilized powders. In half of the samples, a rich in carnosol/carnosic acid antioxidant, naturally extracted from rosemary, was added to prevent the powders from lipid oxidation at a concentration of 150 $mg_{carnasol/carnosic\ acid}/kg_{lipids}$ which is the maximum allowed concentration according to the EFSA regulations. Samples were packed in multilayer pouches (PET12/ALU80/PE80) and accelerated shelf-life tests were performed at a temperature range of 20-50ºC and water activity range of a_w=0.11-0.53. The efficiency of antioxidants was determined in terms of lipid oxidation (peroxide value, p-Anisidine, K_{232}, K_{270}), colour and sensory characteristics of the products.
Fish powders were rich in fish oil (64.6%) and, DHA and EPA represented about 20% of fatty acids. Increasing both temperature and water activity resulted in increased lipid oxidation constant rates, up to 1.5-fold at constant T=20?C, and up to 2-fold at constant aw=0.22, respectively. The addition of antioxidant in powders inhibited primary and secondary oxidation ($k_{without,antiox}$=0.85 d^{-1}, $k_{with,antiox}$=0.25 d^{-1} at 20ºC and a_w=0.22), resulting in an increase in the estimated shelf-life up to 45 d. Both high temperature and aw resulted in more intense color changes over storage time.
Fish industry side-streams are rich sources of ω-3 fatty acids, suitable for further valorization as food ingredients. The incorporation of rosemary antioxidant could significantly control oxidative degradation of the developed fish powders and increase their shelf-life up to 50%.

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Special Session

Poster

Protein solubilization and rheological behavior in macro- and microalgae

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With protein contents higher than 30% for microalgae and between 10 – 30 % for some red seaweeds, algae are a commercially interesting source of protein for food and feed applications. However, the poor protein digestibility and solubilization yield of algae protein remains a challenge in the food industry. The low degree of solubilization associated with the processing needed to increase this yield often impairs their use and soy proteins are still the preferred option when considering alternative proteins. Also, its solubility influences other functional properties (e.g., emulsifying/foaming capacity and aggregation state), being determined by the amino acids' composition, native/denatured state, molecular weight, and environmental factors (e.g., temperature and pH).
This work aimed at improving the solubility of different macro (Porphyra dioica, Palmaria palmata, and Gracilaria verrucosa) and microalgae (Chlorella vulgaris, Nannochloropsis oceanica, and Tetraselmis chuii) protein fractions using different approaches. Preliminary tests using Osborne fractionation indicated that algae proteins may be solubilized in water and alkaline solutions and not in salt or ethanol. Therefore, the pre-treatments were applied to maximize protein extraction with minimal impact on the technological functional properties using water or alkali. Tested pre-treatments included grinding, freezing/thawing, ultrasounds, enzymes, homogenization centrifugation, and pH shift alone or in different combinations.
The solubilized extracts were characterized in terms of solubilization yield, protein recovery, protein content and molecular weight. Gelling and emulsifying potential were also assessed for the extracts with higher protein content.
For macroalgae. protein solubilization was higher when considering water as solvent combined with other pre-treatments, with protein recoveries up to 40 %. For the considered microalgae, better results were obtained with 4 freezing/thawing cycles with extraction yields up to 20%.
The final protein extracts presented interesting emulsifying and gelling ability with possible applications as food or ingredients.
Acknowledgements: This work was financially supported by the project BioEcoNorte (ref. NORTE-01-0145-FEDER-000070), co-funded by NORTE2020, Portugal 2020 and ESIF - European Structural and Investment Funds European Union, through the CCDRN. Catarina Moreira and Rafaela Nunes are recipients of a Ph.D. scholarship supported by FCT (Ref. 2021.05734.BD and SFRH/BD/07527/2020, respectively).
Catarina Moreira and Rafaela Nunes contributed equally for this study.

Special Session

Poster

Optimization of hydrothermal hydrolysis of fish by-products for obtaining bioactive protein enriched hydrolysates

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Fish by-products produced from fishing industry are estimated to represent 60 % (by mass) of total processed fish. These products are rich in proteins (49 to 57 % by mass), which could be further used in food and feed nutrition or nutraceuticals. Hydrolysis can be used to solubilize and increase the digestibility of these proteins. Further, the resulting protein hydrolysates frequently present interesting bioactive features and functional properties, commonly ascribed to the liberation of bioactive peptides.

The present work aimed at the optimization of hydrothermal hydrolysis treatment parameters for the preparation of bioactive fish protein hydrolysates from industry by-products. Samples were previously grinded and de-oiled by centrifugation. Initially, time and temperature were the parameters considered in order to achieve an optimal condition. Further process intensification was made considering different solid loads to increase the process feasibility. Biomass solubilization yields were determined gravimetrically and all end products were analyzed for their ash and protein contents. Peptides' profile in the hydrolysates was evaluated by high performance liquid chromatography (HPLC). Bioactivity of hydrolysates were also assessed in vitro considering antioxidant and antihypertensive activities using colorimetric assays. Results showed that solubilization yields ranged from 40 to 85 % and the hydrolysates produced have high protein content (ranging from 60 to 95 % w/w), with interesting nutritional and antioxidant features. The protein solubilization and hydrolysis patterns are in accordance with the peptides' profiles obtained.

Hydrothermal hydrolysis of fish by-products resulted in the production of hydrolysates with potential applications in human or animal nutrition, using a potentially environmentally friendly and easily scalable process. However, the final choice of the optimal condition should consider a balance between feasibility, bioactivity, functionality, expected bitterness and environmental impact (including energetic costs).

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Special Session

Poster

CLARIFICATION OF RAW BITTER ACIDS EXTRACT FROM HOT TRUB BY-PRODUCT VIA MICROFILTRATION AND MICROFILTRATION ADDED OF DIAFILTRATION

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Membrane technologies are widely used in food industry, effluent treatment and food research, concerning clarification approaches and adding value to phytochemical extracts from agro-food by-products and wastewater. Beer by-products have a high nutritional value and phytochemicals composition that still are little reused. Among these phytochemicals are bitter acids that promote bitter flavor as also colloidal and antimicrobial stability to beer, although high quantities of them are lost from hot-trub after the wort-boiled step. Because of that, this study had as goal the removal of suspended particles of bitter acids extract that could negatively interfere with the product's visual quality (promoting haze) and concentration processes. The first step was the production of an ethanolic extract of bitter acids by mixtures of hydroalcoholic solution at 30%(v/v) and hot-trub by-product with adjustment to pH 7. The bitter acids extract was submitted to microfiltration (MF), and MF added with diafiltration (MF/DF) using flat sheet membranes (MV020/NADIR) in a crossflow system (operation conditions: pressure=4 bar to MF; 4 and 5 bar to MF/DF; temperature=25°C; flow rate of recirculation=80L/h). The MF allowed ~69% of bitter acids to permeate, while the MF/DF reached 81%–92%. This improvement in permeation can be seen in MF/DF treatment at a pressure of 5bar. In addition, the MF membrane was efficient in removing the suspended particles with size of ~10µm, altering significantly the permeate fraction color parameters. However, these particles' retention contributed to the decrease of permeate flux of approx. 90% after 15 minutes of filtration to all treatments, suggesting that fouling caused by them was intense. After membrane cleaning processes and fouling characterization, it was observed that the foulant layer was strongly linked with membrane, which altered the chemical compositions, morphology, and hydrophobicity of its surface after filtrations. The foulant layer was composed of a mix of nitrogen compounds and substances with carboxyl groups, indicating the deposition of proteins, bitter acids, and sugars. Therefore, MF and MF/DF were highly efficient in promoting the clarification of raw bitter acid extract, although just MF/DF treatment showed a high permeation of bitter acids with a decrease in alcohol content from 30 to 15% (v/v).

Special Session

Poster

Cascading extraction: a way to simultaneously increase market value and decrease the environmental constraints of hydrocolloid recovery from red seaweeds

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Agarophyte seaweeds are industrially exploited for their hydrocolloids, but the residues are discarded by the tons. Moreover, there is barely available data regarding the extraction of proteins, lipids, phenolics and pigments from these biomasses prior to agar extraction, leaving a huge gap surrounding the influence of each step on the composition and function of the main product (agar).
The aim of this work was to evaluate the effect of several extraction procedures (cold-water targeting protein recovery, ethanolic solvent targeting pigment recovery and moderate alkali targeting protein recovery), alone and in several combinations, on the agars from Gelidium sesquipedale and Gracilaria vermiculophyla. Yield, texturizing and rheological properties, and structure (FTIR, molecular weight) of the hydrocolloids were evaluated. For control purposes, a direct agar extraction was performed. Side-streams were analyzed for proximal composition, nutritional value and bioactivity (antioxidant activity).
For Gracilaria vermiculophyla, sequential use of cold water and ethanol proved to be the most beneficial approach, without any impact on the agar's quality. For Gelidium sesquipedale, sequential use of cold water, ethanol and moderate alkali extraction proved to be significantly helpful, due to an increase in gelling strength and rheological behaviour, without yield loss. Using this optimized procedure, per 100 g of original biomass, 22 g of agar with 1150 g/cm2 gelling strength, gelling temperature of 34 oC, melting temperature of 95 oC and a purification degree near 90 % are obtained. Alongside this industrially relevant product, 376 mg of phenolic compounds (as gallic acid equivalents), 4.4 g of solubilized proteins and 3.8 g of solubilized sugars are recovered in the initial extraction procedures, with antioxidant activities reaching 1 mM/L (Trolox equivalents), demonstrating the potential market value of these additional fractions.
Overall, the sequential extractions employed, when optimized, proved to be capable of providing additional highly desirable side products, without compromising the potential uses of the main product, being a good alternative for the beginning of a cascading biorefinery approach for red seaweeds.
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Special Session

Poster

Waste-to-Food Strategies: design, application and sustainability

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The concept of Waste-to-Food conversion as a new approach to efficiently utilize organic waste and return nutrients in the food chains in as close way as possible to the human consumption. The current principle of cascading use of biomass considers a formation of food and feed, prior to the production of materials and chemicals as well as energy. Cascading use of biomass shall promote efficient use of bio-based resources through dissemination of best practices and support for innovation in the bio-economy and follow the principles sustainability, resource efficiency, circularity, new markets and products as well as subsidiarity. However, existing approaches do not rely on direct utilization of waste biomass for human consumption, but rather for the reuse of nutrients and chemicals through biotransformation or chemical alteration.
Reducing food waste can provide multiple benefits for both society and the globe, being mandatory to find ways to increase the efficiency of the food system, security, and nutrition, and to contribute towards environmental sustainability. Results of a few international and regional projects (e.g., EntoWaste, UpWaste, ClimAqua, AlgoWert) dealing with the application of bio-transforming agents (e.g., microalgae and insects) indicate high sustainable potential for the waste reuse into the safe biomass applicable in food chains. The application of Waste-to-Food concept relies on known and novel solutions focusing on nexus approaches to the utilization of biobased materials and methods. Safe and economically feasible examples include the use of food waste for the heterotrophic microalgae (Galdieria sulphuraria) cultivation or insect (Hermetia illucens) production. Such approaches allow for the holistic reduction of environmental impact (20-30%) if multiple reuse options are considered. The results also indicated the most feasible options of the Waste-to-Food application options for the industrial symbiosis and circular economy benefits.

Special Session

Poster

Recovery of fruits affected by postharvest disorders for the production of crispy air-dried pear rings

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During long-term storage in air (NA) and in controlled atmosphere (CA), Abate Fetel pears can develop physiological disorders, especially superficial scald. Fruit affected by this disorder are unmarketable but could be used to produce dried rings, as this defect affects mainly the fruit peel.
The objective of this research was to evaluate the quality of air-dried pear rings obtained from defected pears. 120 pears were classified in less-, medium- and more-mature, by time resolved reflectance spectroscopy and stored for 6 months at −1°C in NA and in CA (8-14% O_2 + 1% CO_2). At the end of the storage, pears were examined for physiological disorders and defected fruit were processed. Three 4 mm thick rings/fruit were air-dried at 80°C up to a constant weight using a pilot air circulated drier. Moisture content (mc), water activity (aw), mechanical and acoustic properties of dried rings were measured.
About 73% of NA-fruit and 81% of CA-fruit were affected by superficial scald; this disorder was shown by 95% of the less-mature pears and 68% of the more-mature ones.
Dried rings were characterized by an extremely low mc (1-1,2 %) coupled with a very low aw (0,07-0,10). Mc and aw were higher in dried rings produced from CA pears, especially from more-mature ones.
Air-dried rings, submitted to a breaking test, showed low hardness values, while they always produced sounds events, though with varying number and average pressure levels (SPL), indicating a crisp product.
Dried rings showed low hardness (4,4-4,8 N) without differences between atmosphere and maturity, and a gradient range of 3,94-5,67 N/mm, higher in NA and in less-mature rings.
The number of sound events was lower in NA (3,7-5) dried rings but with higher average SPL (74-76,5 dB) than in CA ones (n=6,2-8,7; SPL=69-71,8 dB). Highest sound events were found in more- mature CA dried rings, while highest SPL were observed in less-mature NA ones.
Our research showed that pears affected by superficial scald can be processed to produce a crispy snack, a healthy product with good marketing perspectives and economically advantageous for producers.
This work was supported by ESPERA Project-Regione Lombardia.

Special Session

Poster

High-Moisture Meat Analogues from Rapeseed and Pea Protein Blends

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Rapeseed protein is not currently utilized for food applications, although it has excellent physicochemical, functional, and nutritional properties similar to soy protein. Thus, the goal of this study was to create new plant-based meat analogues from a 50:50 blend of rapeseed protein concentrate (RPC) and yellow pea isolate (YPI) using high-moisture-extrusion (HME) cooking with a twin-screw extruder to gain a better understanding of the properties of the protein powders and resulting meat analogues. The effects of extrusion processing parameters such as moisture content (60%, 63%, 65%, 70%), screw speed (500, 700, and 900 rpm), and a barrel temperature pro?le of 40–80–130–150 °C on the meat analogues' characteristics were studied. When compared to the effect of varying screw speeds, targeted moisture content had a larger impact on textural characteristics. The extrudates had a greater hardness at the same moisture content when the screw speed was reduced. The speci?c mechanical energy (SME) increased as the screw speed increased, while increased moisture content resulted in a small reduction in SME. The lightness (L*) of most samples was found to increase as the target moisture content increased from 60% to 70%. The RPC:YPI blend was equivalent to proteins produced from other sources and comparable to the FAO/WHO standard requirements.

Special Session

Poster

An orange by-product flour as a stabiliser of oil-in-water emulsions

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This research aimed to evaluate the use of an orange by-product flour (OBF), rich in pectins (22 g/100 g dry matter (dm)) and with high antioxidant activity (28 mg TROLOX equivalent/g dm) in the formulation of oil-in-water emulsions (6 % oil w/w). The OBF was obtained after extracting the orange juice and blanching, freeze-drying, and milling (<0.5mm) the remained pulp and peel. Different concentrations of OBF in the emulsions were evaluated (1.0, 2.4, and 3.4 % w/w named 1.0OBF, 2.4OBF, and 3.4OBF, respectively) by comparing them with a control emulsion prepared with a synthetic emulsifier (Tween®20) (0.21 % w/w). The emulsions were assessed in terms of apparent viscosity (rotational viscometry), Z potential (electrophoretic mobility), droplet size distribution and flocculation after their preparation and 24 h later (optical microscopy and image analysis), and creaming after 24 h. ANOVA and Tukey tests were applied to evaluate differences ($p<0.05$) among the emulsions. The addition of OBF significantly ($p<0.05$) increased the viscosity of the emulsion compared with the control (152±6 mPa·s) only for 3.4OBF (211±1 mPa·s). Similarly, the Z potential absolute value was only significantly higher than the control (-15.8±0.9 mV) for 3.4OBF (-19.7±1.3 mV). The control showed the smallest droplet (median diameter 2.4±0.1 µm) and 1.0OBF and 2.4OBF the largest (10.8±0.4 µm), increasing the OBF concentration up to 3.4 % resulting in a 30 % decrease of the droplet size comparing with 1.0OBF (7.7±0.1 µm). The control was highly flocculated (41 %) while emulsions containing OBF showed no flocculation. No differences ($p>0.05$) in the median diameter after 24 h was observed in control and 3.4OBF, while 1.0OBF and 2.4OBF showed 75 and 16 % median diameter increases, respectively. No creaming was observed in 3.4OBF while control, 1.0OBF, and 2.4OBF showed high values of creaming index (63, 77, and 50 %, respectively). Overall, the use of the OBF allowed to obtain a more stable emulsion than the one formulated with a synthetic emulsifier depending on the concentration of the material, being more stable the emulsion prepared with 3.4 % OBF, and also provided antioxidant capacity which might protect the oil from oxidation.

Special Session

Poster

Label-free Biomarkers of post-mortem aging and salt processing in fish to improve processes and food properties

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Predicting the metabolic shifts induced by post-mortem changes or various processing methods is crucial in maximizing food performance. This study aims to better understand the characteristics of trout river fish muscle, in salted and non-salted fillet, over the post-mortem aging. To do so, a comprehensive analysis (multi-scale multi-disciplinary) was performed to assess the structural and biochemical properties of fish filet over 15 days. Surprisingly, the post-mortem time impacted very little the denaturation of proteins and tissues micro-structures. However, post-mortem aging was responsible for quicker absorption of the salt, as HPLC analyses showed the salt concentration in aged samples was 2 to 4 times higher than at the beginning of the post-mortem time. Additionally, dry-salting caused a strong denaturation of the structural properties of muscles. Finally, label-free spectroscopy (FTIR) was used to detect slow metabolic shifts in tissues. Spectral fingerprints were processed with machine learning to predict with high confidence the biomarkers of post-mortem aging and salting. Data were then correlated to conventional biochemical analyses. We conclude that better food performance can be achieved by adapting processes accordingly to the structural and biochemical characteristics of the fillet.

Special Session

Poster

Life Cycle Assessment of the coffee production process in the context of energy savings and circular economy

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In the coffee industry, the high demand of energy consumption and the waste created by the processing of coffee beans have created an increasing environmental concern worldwide. The highest energy consumption is observed in the stage of roasting in which the consuming thermal energy derived from the combustion of fossil fuels in order to heat the air to a temperature of about 220°C. This hot stream is usually discharged into the atmosphere. In addition, this process produces a by-product named silverskin creating significant amount of wastes. This by-product is usually being used in fertilizers, but it has the potential to be used for energy production and for the extraction of valuable components. In the present study, energy reduction solutions related to the recycling of hot streams as well as the utilization of silverskin by-product for energy production and for the development of high-added value products were evaluated in the context of circular economy. The proposed solutions were evaluated in terms of their environmental footprint and the comparison with the conventional production line was performed. Life Cycle Assessment was implemented according to ISO 14040 & 14044, using GaBi software, utilizing ReCiPe 2016 (H)* methodology with 18 midpoints and 3 endpoints. To this end, to define the Goal of the study, Cradle-to-gate boundaries were set and the functional unit was defined as 1 kg of the produced coffee. The results of the examined cases revealed that the environmental impacts were lower with the implementation of the proposed solutions in the coffee production line compared with the conventional one. The solutions that proved to be more efficient were the use of heat pump for the recycling of hot streams from roasting process and the utilization of husks for the replacement of a part of fossil fuels and as a valuable source of bioactive compounds with high antioxidant activity (1.92 mmol Trolox/100g dw).

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Special Session

Poster

Development of sustainable active packaging

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Keywords: Starch, microencapsulation, essential oil, eco-friendly,

In order to reduce the environmental problems that arise from the excessive use of plastics and contribute to the extension of the shelf life of foods without the addition of synthetic additives, the packaging of sustainable and/or biodegradable materials have emerged in national and international research. This being said, the present work aimed to encapsulate thyme essential oil and incorporate the particles into a starch film. For the development of the active film, the particles were produced by the complex coacervation method and their characteristics such as efficiency and morphology were evaluated. The films were activated with 5% microparticles and characterized for their mecanical structure, microscopy and their antimicrobial activity by the agar diffusion method. Antimicrobial activity was observed only in the film incorporated with Thymol microparticles. Thus, it can be inferred that the antimicrobial action of the starch film against the tested microorganisms: the gram-positive bacteria Staphylococcus aures, gram-negative Escherichia coli and the fungus Penicillium sp. are directly linked to the antimicrobial effect of the Thymol microparticles. That said, the antimicrobial starch active film is a natural and environmentally friendly option for food preservation.

Special Session

Poster

Adding value to tomato pomace via enzyme-assisted aqueous extraction

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The food industry is increasingly concerned with operational sustainability and food waste reduction. In the United States, the massive tomato industry was worth $1 billion in 2020. Tomato processors have striven to valorize pomace by-products, which contain seeds with valuable compounds such as 30% oil. Tomato seeds are rich in bioactive compounds. Meanwhile, global edible oil production is forecasted to reach 632 million tons in 2022, and there is increasing interest to produce specialty oils. Organic solvent extractions are commonly used to extract oils from various commodities, but this method comes with some environmental concerns. Enzyme-assisted aqueous extractions (EAEP) have been proposed as a green alternative to oilseed solvent extractions. The objectives of this research were 1) to determine the impact of various extraction factors on oil yields from EAEP of tomato seeds; 2) to evaluate the effect of aqueous extractions on oil quality, and 3) to establish whether these processing steps are economically feasible for industrial commercialization.
The highest oil yield (41%) was obtained during 2 h extractions at pH 9, which were 68% higher than from 2 h extractions performed at pH 3. Enzyme addition was only beneficial during 8 h extractions of tomato seeds (4% cellulase, pH 3), which led to 53% higher oil yield compared to the control. Increasing incubation time from 2 to 8 h improved oil yields to 63% and 69% for cellulase extractions and protease extractions, respectively.
The pH of the aqueous extractions did not have a significant effect on the quality parameters of the extracted tomato oils, except for polyphenol content, DPPH production, peroxide, and TBARS values. Overall, tomato oil had peroxide and free fatty acid values comparable to other specialty oils, such as sunflower and sesame oils. From a techno-economic point of view, tomato oil production at a flow rate of 1,752,000 kg pomace/yr garnered $13 million in profit after a payback time of 1.6 years, which was more profitable than the industry’s current pomace disposal practice. Sustainable strategies of how tomato by-products could be repurposed to reduce waste and make value-added food products were demonstrated.

Special Session

Poster

No more words, let's cook with crickets: the optimization of cricket-based cookies and taralli

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The advantages of consuming insects are well known by everyone worldwide. They are mainly related to health, environment, and livelihood. Also, insects are highly considered tasty for Asian and African people, which consume them, both as the whole form and as ingredients. On the other hand, Western people still view entomophagy with feelings of disgust, even though they realize all the advantages related to edible insect consumption.
To date, the scientific community and food companies have all the instruments and data to develop new insect-based food products. An appropriate product design could improve the acceptability of new foods. For example, using edible insects as powder could be a good starting point to encourage people to consume new insect-based foods.
The present work aimed to optimise the formula of two insect-based foods: sweet cookies and salty "*taralli*". For the preparation of both products, traditional flour was replaced with different percentages of cricket powder (7 samples in both cases);. A three-component constrained simplex lattice design was used to obtain different formulations to be tested. Cookies were tested by 22 assessors by following the Ideal Profile Method; Taralli were tested by 14 assessors by following the Ultra Flash Profile Method. To optimize the formula, the desirability function (the best compensation of the ingredients to achieve ideal intensity from every single attribute) was used and the Ideal scores for each attribute were set to be targets to generate the optimal conditions. In the case of cookies, formulation with 37.7% wheat flour, 5.4% cricket flour and 23.8% butter was proposed to achieve 0.602 of desirability. On the other hand, in the case of *taralli*, the formulation with 56% of wheat flour, 6% of cricket powder and 22% of water was found as the optimal formulation with a desirability value of 0.74. In both cases, cricket powder significantly affected both colour and texture.
In conclusion, cricket powder influences the sensory characteristics of cookies and *taralli*, and needs to be sensibly used to meet the ideal profile. However, cricket powder results in a potential substitute for traditional flour for both sweet and salty products.

Special Session

Poster

Profile of primary metabolic components of edible crickets fed with vegetable powders

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Crickets are recommended for alternative protein source because of high production efficiency and low environmental impact. However, relationships between breeding condition of crickets and their quality as a food stuff are unclear. In addition, feeding crickets with food waste is discussed because they are omnivorous. This study explored the possibility of increase in the quality, especially for the nutritional value, through effective food selection. Young house crickets (*Acheta domestica*) were used for the experiments. The crickets were bred with enough amounts of water and commercial feed for 2 weeks as a control group. Additionally, 3 groups were set up in which 10% of the feed was replaced with carrot, yuzu citrus and purple sweet potato powders, respectively. After the breeding, all the crickets were freeze-dried and powdered. Then, hydrophilic metabolites were extracted from each powder, and conducted metabolome analysis by using a GCMS-TQ8040NX. This analysis was based on Smart Metabolites Database made by Shimazu, and primary metabolites such as amino acid, fatty acid and sugar were targeted. As a result, more than 95 kinds of components were successfully detected. Feeding purple sweet potato powder during the growth significantly increased essential amino acids such as leucine, isoleucine, lysine, phenylalanine, tryptophan as well as malic acid and sucrose. Some concentrations of them were not higher in powder than in other vegetable powders and the commercial feed (ex. leucine, malic acid). It was suggested that the powder highly affected biosynthesis and metabolome relating such metabolites. On the other hand, some components like phenylalanine and sucrose seemed to be enhanced by accumulation with intake. The potato powder contained much amount of them, and the crickets grown with the powder indicated high concentration of the components. In conclusion, high nutrition crickets would be produced by choosing feed effectively.

Special Session

Poster

Cardboard container formulated with oregano oil for the inhibition of the fungus (Colletotrichum gloeosporioides) in Hass Avocado (Persea americana)

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The globalization of markets, the growth of exports in Colombia, the restrictions on the use of pesticides in Europe, and the deterioration of fruits caused by fungi are fundamental aspects that make it necessary to develop new packaging alternatives for the conservation of avocado during its commercialization, exploring the use of natural fungicides such as essential oils. The objective of the present study was to develop an active packaging from cardboard with a coating based on modified cassava starch, glycerol, and essential oil of oregano (EOO) to evaluate the inhibition of the fungus *Colletotrichum gloeosporioides* (CG) and quality parameters in packaging avocados. For the study, cardboard pieces of 30 mm x 30 mm were cut, and the coating was applied with four treatments, coating without EOO (T0), coating with 1.5% EOO (T1), with 2.5% (T2), and 3.5% (T3), the sheets adhered to the lids of the Petri dish, the fungus (CG) was inoculated. The percentage of inhibition of its growth was determined at room temperature for 12 days to determine the concentration of oregano to apply in the boxes for the shelf life studies. The results showed that different concentrations of EOO decrease the mycelium growth of the C.G fungus in a petri dish, giving % inhibitions equivalent to 0.78±1.73 for T0 and 2.88±2.93, 13.29±6.76 and 65.94±32.92. % for T1, T2, and T3, respectively. When taking the avocados to storage in the active container with 3.5% (T3) and without essential oil (T0), the active container made with corrugated cardboard and EOO at 3.5.% does not negatively affect the physicochemical quality of the fruit stored. No affectation by the CG fungus was observed in the avocados during 22 days at 9 and 25 °C, while the avocados stored in the boxes of the T0 treatment presented deterioration by the fungus in 20% of the fruits. It can be concluded that it is possible to develop an active container with corrugated cardboard boxes coated with modified cassava starch and essential oil of oregano and delay the incidence of the fungus Colletotrichum gloeosporioides during the commercialization of avocados.

Poster

Enzymatic hydrolysis of salmon frame proteins at different byproduct/water ratios and pH regimes

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The enzymatic hydrolysis of proteins is an interesting alternative to add value to the salmon frames by converting this by-product into protein hydrolysate and bones. The protein hydrolysates are recognized sources of bioactive peptides. In adittion, bones can be transformed into a viable calcium source through nano milling. During the hydrolysis the mixing is favored by the addition of water, meanwhile, the cost is highly increased during the drying stage. The addition of alkali avoids the pH drop causing enzyme activity to decrease, meanwhile, the operation cost is increased.
The evaluation of different by-product/water ratios was assessed using 50%, 75%, and 100% of ground salmon frames. The pH regimes were set up at controlled pH 8, initial pH 8 without control, and native initial pH without control. The hydrolysis reactions were carried out at 55 °C in an agitated batch reactor using 13 AU subtilisin per kg salmon frame. Response variables were released alpha-amino groups, mass of soluble/insoluble fraction, and nitrogen extraction.
The results showed that the released alpha-amino groups were 129, 108, and 87.9 mmol/kg of reaction mixture at 60 min for the regimes of controlled pH 8, initial pH 8 without control, and native initial pH without control, respectively. The results for the different salmon frame concentrations (native initial pH without control) yielded 189, 159, and 87.9 mmol/kg of the reaction mixture at 60 min for 100%, 75%, and 50% of salmon frames. The hydrolysis without pH control allowed to avoid the use of alkali and control system but decreasing the production of amino groups at 68% of the controlled condition. The hydrolysis at high salmon frame concentration allowed to avoid the addition of water. However, the productivity obtained was 189, 212, and 176 mmol/kg of the salmon frame at 60 min for 100%, 75%, and 50% of salmon frames. These results can be used to estimate the profitability of the process after considering the decrease in the operational cost and the effects on the product yield.

Special Session

Poster

Green coconut (Cocos nucifera L.) as emulsifier replacer in pan bread

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The edible pulp and the husk generated after extracting the water of green coconut are mainly disposed at the soil, representing a challenge for all the production chains. Environmental awareness encourages studies of food waste for several uses, generating value and promoting a circular economy. Previous studies showed the foaming and emulsifying capacity of green coconut pulp. The foaming capacity is a typical protein property; however, the presence of fat reduced this property but not the foam stability. While the emulsion capacity is only a protein property, and it could be changed by pH, ionic strength, temperature, concentration, and solubility. The objective of this study was to evaluate the green coconut pulp as an emulsifier in pan bread and compared it with distilled monoglycerides.
The proximal content of green coconut pulp was 89.8% water, 0.9% protein, 2.6% lipids, 0.76% ash, and 5.94% carbohydrate. It was dried in a spray dryer (SD-05, RPM, Brazil) from a paste with 25% of a carrier (1 arabic gum, Synth: 3 modified starch, Capsul®Ingredion), 25% of water, and 50% pulp; and in a freeze dryer (LV2000-Terroni, Brazil) at 25 mHg and -50°C for 20h. The bread loaves were made from wheat flour, water, salt, sugar, oil, dried yeast, and a commercial flour improver (control-C). The distilled monoglycerides (DM-0.3%, flour basis) or green coconut pulp; frozen (FP-10%), spray-dried (SD-6.2%), and freeze-dried (FD-1.1%); were added and the pulp solids were kept constant in FP, SD, and FD formulations. The bread loaves were evaluated according to specific volume, center height, and firmness (AACC, 1995).
Bread from FP presented the highest specific volume (5.0 $cm^3 \times g^{-1}$), and FD and SD were not statistically different from DM ($p>0.05$). All formulations with coconut pulp and monoglycerides presented higher values than C. The greatest height was of SD and FD, besides FP was not statistically different from DM. The lower firmness was presented by SD, but with no difference from FP, and FP was similar to DM. The results indicate that the green coconut pulp, in its different forms, is a promising replacer of distilled monoglyceride in pan bread.

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Special Session

Poster

White grape (Vitis vinifera) pomace powder characterization for use as an ingredient in bakery products

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In white winemaking, the grape pomace, obtained from pressing Viognier variety, pretreated with metabisulfite, consists of skins, seeds, and a high amount of residual sugars, because the juice is removed before fermentation. The pomace use is important for the environment and the economy since it would not be disposed on the soil and it would create value for circular economy development. The objective was to obtain and characterize flour from grape pomace, which composition depends on the pressing equipment. There were evaluated two pomace pressing degrees, with water content of 72.4 g/100g (HW) and 68.5 g/100g (LW). The HW was dried for 48h and the lowest for 24h at 45°C in an air-drying oven. Dried samples with 7.0 g/100g and 5.2 g/100g respectively, were milled in a domestic grinder and the powders were characterized according to water content, water activity, color, particle size, and flowability.

The water activity and CIELAB coordinates were higher for HW, due to the higher residual sugar content and Maillard reaction. The higher sugar content also indicates a powder agglomeration, which resulted in better flowability (LW: poor and HW: tolerable), facilitating its processing and storage. Despite these results, the lower sugar content of LW powder would be interesting to focus on high fiber content in low sugar products, by partial substitution of wheat flour. The substitution may alter the viscoelastic behavior of dough and the textural and sensory properties of baked goods containing grape pomace flour depending on the addition level and particle size. The LW presented a Sauter diameter of 360mm, closer to 250mm, which is the average diameter for wheat flour. The substitution of wheat flour with non-gluten white grape pomace flour will improve the product's nutritional value because of its fiber content. Since fruit pomace flour turns the dough less extensible and more tenacious, compromising the bread specific volume, the substitution would have a good effect in products like cakes and biscuits, in which gluten formation was not important. The white grape pomace does not incorporate sensorial grape taste and color characteristics, allowing its use in neutral flavors.

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Special Session

Poster

Preparation of starch-based films from sweet potato starch with the addition of lemon peel pectin

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The use of petroleum-based plastic around the world has increased multiple folds and poses enormous risks to the environment due to its toxicity and non-biodegradability. The possible solution to this problem could be the production of biodegradable materials. Starch is a great polymeric material to be utilized for producing biodegradable films and is abundantly found in plant cells. However, these starch films alone have few mechanical limitations. So, the starch films can be blended with other bio-polymeric materials i.e., pectin to improve its film-forming properties by cross-link structure. In current study, pectin-starch films were extruded by employing pectin and starch extracted from lemons and sweet potatoes, respectively. Eight film combinations were prepared by using three different ratios of starch and pectin with and without ultrasound (US) application to the film forming solution. These films were characterized to obtain the most suitable combination of the film having acceptable physical and mechanical properties. The obtained results showed an insignificant ($P>0.05$) effect of all treatments on the properties of the film. The statistical analysis of films indicated that T5 (1:1+ US) has acceptable mechanical, optical and biodegradable properties. Furthermore, it was also observed that starch films prepared with pectin demonstrated better properties than starch films alone. Also, the application of US appeared as a beneficial approach for improvement in strength, opacity and degradability of films.

Special Session

Poster

Optimal Operation in an Integrated Food Processing: A Strategy Development

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Sustainability in industries has become a motivation for companies' business model development. A practical approach to address sustainability in an industry is to perform gate to gate material and energy analysis to minimise the consumption and increase the efficiency of the process.

Food industries have a dynamic nature that it is impossible to separate the operation impacts on sustainability. A good example can be explained by focusing on sustainability pillars, production, and cleaning sequences. Production is mainly driven by economy, which is connected to market's supply and demand and its uncertainties due to material and utility prices. Cleaning and sterilising cycles are essential and expensive which covers the quality of the products. Most of the cleaning and sterilising are currently performed based on general recommendations for a series of products and usually it includes several cycles of acidic, basic and water usage. Its mechanism is complex due to impact of several parameters including previous production cycle. Hence, to achieve certain level of sustainability focusing on both production and cleaning is essential.

More complexity accounts when we look at the whole process line. As an example, for a conventional Ultra-High Thermal (UHT) processing dairy line with four products, there are about 6-8 separate cleaning sequences. This leads to more than 100 alternative operational selections which can be reduced by technical constraints. Besides that, there are other operational choices that can be added by automation, for example type of utility control in case of the Fouling in heat exchanger network to keep the product temperature constant. Other decisions factors can be added by plant manager to perform intermediate or full cleaning, and production, cleaning, and sterilising time to a certain level. Another practical challenge is how to utilise a massive information available from instrumentation in the form of plant data. As the process lines are usually tailored based on customer requirements, identify the necessary information/instrumentation is required.
In this paper which address a strategy development to recognize key information needed to develop a tool that can help to study a process line to improve decision making focusing on a dairy UHT line.

Special Session

Poster

In vitro assessment of the antimicrobial activity of ultrasound-assisted extracts of aromatic plants by-products against microbiota isolated on selective media from spoiled vacuum – packaged cooked meat.

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Objective: One of the most common causes of food-spoilage and their short shelf-life is related to microbiological origin. On the other hand, the consumer trend for fewer artificial food additives is well recognized. Therefore, systematic scientific efforts are carried out to find alternative methods to inhibit both pathogenic and spoilage microorganisms. The antimicrobial activity of ultrasound-assisted extracts of aromatic plants by-products was tested against selected bacteria isolated from spoiled vacuum-packed cooked meat on selective media.
Methods: Spoiled vacuum-packed pork meat was microbiologically analyzed, and the dispersion was spread plated on the selective agar plates that were incubated under the proper conditions. The majority of isolated colonies belonged to species Lactiplantibacillus plantarum, Latilactobacillus sakei, Brochothrix thermosphacta and Carnobacterium divergens. The antimicrobial efficacy of the extracts was evaluated in a microplate spectrophotometer at 600 nm over 24 h at 30 min intervals. The final concentration of the extracts was 4%, 2% or 1% v/v and the initial population of the target strains was approx. 104 cfu/mL. The Baranyi and Roberts growth model was applied and the lag phase was calculated. The inhibitory activity was estimated in comparison to that of the control samples. The longest the lag phase, the stronger the inhibitory effect.
Results: Results showed that the Origanum vulgare extract had the highest inhibitory activity compared to Rosa Damascena extract. The 4% v/v oregano extract caused 78%, 53%, and 22% increase of the lag phase of Lactiplantibacillus plantarum, Latilactobacillus sakei and Carnobacterium divergens, respectively while no change was observed in the case of Brochothrix thermosphacta. The 2% v/v oregano extract obtained an increase of the lag phase equal to 44% and 25% for Lactiplantibacillus plantarum and Latilactobacillus sakei. Regarding the extracts of rose petals (at 4% v/v) an inhibitory activity was observed only against Lactiplantibacillus plantarum, Latilactobacillus sakei.
Conclusion: The use of aromatic plants by-products can inhibit species of bacteria that participate in the spoilage microbiome of vacuum-packed cooked meat. Nonetheless, in contrast to pathogenic bacteria, it is not necessary to completely inhibit the target microorganisms; the purpose is to delay their growth to extend the shelf-life of the product.

Special Session

Poster

Assessment of the antioxidant/antiradical activity and phytochemical profile of ultrasound-assisted extracts of aromatic plant by-products using spectrophotometric assays and untargeted LC-MS/MS analysis

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Objective: Striving to meet the socioeconomic demands of modern society, the concepts of ''by-product to co-product'' and ''repurpose-upcycle-reuse'' are attracting increasing attention. Therefore, plant by-products comprise an easy-to-access and low-cost source of bioactive compounds, which confer significant health-promoting properties. In this regard, the present study investigates the potential of the re-valorization and incorporation of aromatic plant by-products in the development of novel foods. To fulfill this scope, the objectives of this project are (a) to obtain extracts of aromatic plant by-products by optimizing ultrasound-assisted extraction (UAE) using experimental design models, (b) to evaluate the total phenolic content (TPC), the antioxidant and antiradical activity and (c) to assess their phytochemical profile, by implementing spectrophotometric assays and liquid chromatography-tandem mass spectrometry (LC-MS/MS) analysis, respectively.

Methods: Ultrasound-assisted extraction was applied to acquire extracts from five aromatic plants of Greek flora (i.e. Lavandula angustifolia, Origanum vulgare, Rosa Damascena, Helichrysum stoechas and Crocus sativus) as well as from their by-products disposed after their hydro- or steam- distillation. The extraction parameters (% ethanol content, extraction time, solvent/material ratio and ultrasound power) were optimized, in terms of TPC, using Box-Behnken design. The TPC of all extracts was determined using the Folin-Ciocalteu method, while the antiradical and antioxidant activity were estimated by the ABTS•+ and FRAP method, respectively. The phytochemical profile of selected extracts was also assessed by using an Agilent 1200 HPLC and a 3200 Q TRAP triple-quadrupole linear ion trap mass spectrometer system.

Results: According to our results, ethanol content was the most critical factor for polyphenols extraction from lavender, oregano and rose petals by-products. In all cases, the highest TPC values were achieved at 25 min and 40 mL/g solvent-to-material ratio. Oregano and rose petals extracts presented the higher phenolic content. The untargeted LC-MS/MS analysis revealed the presence of bioactive compounds, such as phenolic acids, flavanones, flavonols and other flavonoids.

Conclusions: Based on their antioxidant properties, aromatic plant by-products emerge as promising agents for novel food applications, such as their use in meat products to inhibit microbial growth and lipid oxidation aiming at a shelf-life extension.

Special Session

Poster

Biopolymer-based films containing emulsified active ingredients as coatings for cellulosic packaging: a review

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Biopolymer-based films containing emulsified active ingredients as coatings for cellulosic packaging: a review

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ABSTRACT

Cellulose materials (paper and paperboard) have been gaining prominence and importance in the food packaging scenario. They are from a renewable source, biodegradable, and produced with relatively low cost. However, these materials have a poor barrier and mechanical properties. To overcome these weakness, plastic or aluminum-based coatings have been applied over these materials. Nevertheless, these composite materials are not biodegradable and are difficult to recycle, resulting in greater environmental impact. Motivated by this, researchers have searched by alternative base for coating cellulosic material. An example of this is the application of coatings based on natural biopolymers, which are biodegradables. However, biopolymers are also sensitive to moisture. In an attempt to solve this problem, there is growing interest in incorporating non-polar components and/or nanoparticle fillers into the coating-forming solution and thus developing an active and innovative packaging. Studies have shown that bioactive components, such as essential oils, added after emulsification into biopolymer-based coating solutions applied to cellulosic materials positively improved their moisture barrier and mechanical properties, and antimicrobial and antioxidant activities. In addition, the use of nanocomposites strengthens the biopolymer structure and can offers remarkable antimicrobial functions to cellulosic material. In this context, this paper will review current knowledge of the progress of the application of natural biopolymer-based coatings combined with bioactive components and/or nanoparticle loading on cellulosic packaging. More understanding of how the coating is developed and applied will allow for improvements of this material and extend the shelf life of the food.

Keywords: Paper, paperboard, sustainability, biopolymers, bioactive components.

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Special Session

Poster

Scale-down of environmental conditions encountered during road transportation in the Canadian food supply chain

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Canada faces unique challenges, in part because of its climate, its long transportation distances and its hundreds of Northern Communities. Major Canadian food retailers reach 82.2% of the Canadian population throughout a four-step road supply chain consisting of growers/suppliers, processors, distribution centers, and retail stores. Few years ago, CanGRASP tool (Canadian GIS-based Risk Assessment, Simulation and Planning for food safety tool) was developed using real field data including namely: product volumes handled by Canadian stakeholder, flow of product between stakeholders, temperatures of product each season, and times products spend in each step or during transit between steps. Such database is costly and laborious to assemble which makes it difficult for the industry to implement road transportation studies in real conditions. The objectives of this study were (1) to scale-down at the pilot plant level the real environmental conditions encountered during road transportation and (2) to assess the impact of random vibrations on the food safety of products. To achieve the scale-down, all the broken cold chain events were identified in the CanGRASP database and quantified using a transient heat transfer approach. This information has been used to create programs into environmental pilot chamber to mimic the heat transfer rates of the real road conditions. A vibration table (0-40G) was placed inside the chamber to generate random vibrations during road transportation as an additional parameter that impacts food product shelf-life. Broken cold chain simulations were conducted on fresh cut lettuce in clamshells inoculated with *Listeria innocua* ATCC 33090 (5-Log cfu/g). Results showed that the environmental pilot chamber can simulate the temperature of real broken cold chain events with a RMSD = 0.09 and a $R^2 > 0.99$. Adding random vibrations can induce an increase of temperature over 2°C due to friction between fresh cut lettuce leaves during road transport simulations. Survival of *Listeria innocua* was not impacted by random vibrations themselves. However, the persistence of *Listeria innocua* inside clamshells throughout the cold chain was affected by the thermal impact of vibration. In the near future, this pilot-scale platform will be made available to allow the industry to conduct their own studies.

Special Session

Poster

Improving Extractability and Functionalities of Rice Proteins Using Enzymatic Treatments

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Objectives
As the second largest-produced cereal, rice (esp. rice bran) is a potential source of gluten-free and hypoallergenic plant proteins. However, technical challenges such as poor extractability and functionality greatly limit the utilization of rice protein ingredients. The objective of this study was to investigate various enzymatic treatments for improving extractability, solubility, and applicability of different rice proteins and transform them into user-friendly food ingredients for novel product development.
Methods
Enzyme-assisted protein extraction was investigated to compare with the traditional extraction techniques. Rice bran protein was extracted from hexane-defatted rice bran by four methods: alkaline extraction at pH 9 followed by acid precipitation at pH 4 (AEIP), ultrasound-assisted extraction (UlsE), Alcalase-assisted extraction (AlcE), and Amylase-assisted extraction (AmyE). The extraction yield and functionalities of the extracted proteins were examined. In addition, transglutaminase (TG) was used to promote applicability of rice proteins in a gluten-free pasta model food system.
Results
Extraction yield, protein recovery, and protein content of AEIP, UlsE, AlcE, and AmyE were (3.1%, 7.4%, 35.44%), (8.2%, 21.6%, 46.98%), (13.5%, 14.8%, 27.68%), and (5.3%, 7.3%, 23.25%), respectively. Solubility of AlcE proteins (62.81-86.15%) was significantly higher ($P < 0.05$) than that of amylase- (9.36-73.78%) and alkaline-extracted proteins (6.79-37.13%).
TG treatment (0-40 U/g) resulted in a 9.8-16.9% decrease in free amines, indicating TG-induced cross-linking in treated rice proteins. This was supported by SDS-PAGE where low molecular weight bands were thinner in TG-treated samples. TG-treated protein samples showed no differences in color, solubility, or water holding capacity. The inclusion of rice protein increased pasta firmness. TG treatment (10U/g) of the proteins further increased pasta firmness at 5% inclusion level but not at the 10% level.
Conclusion
Among the extraction methods tested, protein recovery and purity were the highest in UlsE, while AlcE resulted in the highest yield but compromised by lower protein purity. We recommend using Alcalase hydrolysis to improve protein solubility after UlsE extraction. TG-induced cross-linking in rice protein is promising to mimic the gluten network and significantly improve the texture of gluten-free pasta.

Special Session

Poster

Biodegradability and disintegration of bio-based materials produced with DHT-modified cassava starch

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The development of biodegradable plastics is one of the promising solutions to inadequate waste management practices. Among the different types of biopolymers, starch is massively used to produce these types of materials. However, is well-known that native starches' performance is limited, and the properties of their plastics are not competitive against conventional ones, yet. Among the different types of starch modifications to increase its performance, the dry heating treatment (DHT) is a technique that was proven to enhance the mechanical and barrier properties, mainly related to molecular depolymerization and carbonyl group formation. However, is not described the effect of this type of modification on biodegradability and disintegration behavior. In fact, in the literature, the polymer structure, polymer chain length, and functional groups influence the degradation pattern. Obtaining materials with increased performance is a good achievement, though, those materials must result also in proper rates of degradation, if not the principal problem of plastic waste contamination will not be solved. Therefore, this work aimed to produce bio-based plastic with cassava starch previously modified by dry heating treatment (DHT) and study its disintegration and biodegradation.

Native cassava starch was modified by dry heating treatment (DHT) for (2 and 4) h at 130 °C. Then, bio-based sheets (native and modified) were produced by extrusion in a twin-screw extruder (Thermo Fisher Scientific, Process 11, Germany) with L/D 40, and 11-mm screw diameters. The film disintegration assay was performed for 45 days at 58 °C according to EN ISO 20200, while biodegradation was in accordance with ISO 14855-1. Furthermore, samples of materials were evaluated at different control times to monitor sample weight loss, morphological and mechanical changes, and FTIR spectra.

The main results showed that all the materials showed up to 80 % and 90 % of biodegradation and disintegration, respectively. Moreover, higher rates of both were visualized until day 7, which matches with the microbial growth and disappearance of functional groups. In particular, the DHT4 sheet showed higher rates, which is a great achievement, because DHT4 showed enhanced plastic performance and through this study was proved that also the disintegration and biodegradation process.

Special Session

Poster

Pulsed Electric Fields assisted protein extraction from Tenebrio Molitor: Optimization and effect on colloidal properties

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World´s population is expected to reach 9 billion by 2050, which means a challenge in terms of food production. Due to this problem, different food sources have been investigated to reduce the environmental impact. In this way, edible insects such as Yellow Mealworm (Tenebrio Molitor) have been identified as a source of nutritional compounds for human consumption. In this study, we employed Pulsed Electric Field (PEF) as a non-thermal technology to extract proteins from the Yellow Mealworm. Freeze-dried mealworms were ground and defatted using ethanol. The resulting powder was then mixed with water and PEF treatment was applied using an experimental design (central composite design) with four factors: electric field (from 1.5 to 5 kV/cm), frequency (from 10 to 1000 Hz), number of pulses (from 200 to 1000) and pulse width (from 1000 to 20000; nanosecond). The yield of extraction, biochemical and physicochemical properties of extracted protein as well as their foaming properties are compared and discussed. The possibility to use PEF as a step-on-add for insect protein extraction for industrial applications will be presented.

Keywords: Tenebrio Molitor; pulsed electric field; protein extraction; foaming properties.

Special Session

Poster

Recovering bioactive compounds from pineapple waste: a comparison between pressurizes liquid and supercritical fluid extractions

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Pineapple is a popular fruit consumed worldwide. As a consequence of fruit processing, about 50% of the raw material becomes waste with high potential for recovery of bioactive compounds. In this perspective, this work aimed evaluating high pressure techniques (supercritical fluid extraction (SFE) and pressurized liquid extraction (PLE) to recovery bioactive compounds from pineapple waste. Pineapple waste was formed by peel and bagasse from juice processing. The SFE extractions were performed based on a full factorial experimental design with different levels of pressure (10, 20 and 30 MPa), temperature (40 and 60 °C) and percentage of co-solvent (5% and 15% w/w ethanol). On the other hand, PLE extractions were evaluated at different temperature levels (60, 80 and 100 °C) and ethanol percentage (50, 75 and 100% v/v). The extracts were evaluated for overall yield, phenolic compounds, flavonoid, carotenoid content and antioxidant activity. Then, overall extraction curves (OEC) were performed for the optimized conditions to understand the kinetic behavior of the extraction. It was observed that PLE had the highest overall yield of extract (38.7% w/w), phenolic compounds (9.39 ± 0.56 mg GAE/g RM dw), flavonoids (4.14 ± 0.45 mg EC/g RM dw), carotenoids (26.18 ± 1.04 µg β-carotene/g RM dw) and antioxidant activity. This behavior occurs because PLE uses higher temperature, which increase the mass transfer coefficient. In addition, PLE requires a shorter extraction time and, consequently, there is less degradation of the compounds. Another possibility is that generally hydroalcoholic solutions are more efficient in solubilizing hydrophilic compounds than pure solvents. The determination of the global extraction curves showed that the PLE reaches the diffusional period in times less than 50 min, while the duration of the SFE was approximately 5 times longer for all compounds evaluated. Among the phenolics evaluated the SFE was able to selectively extract ferulic acid (60%) in the optimal extraction condition. Therefore, PLE proved to be the best technique for extracting bioactive compounds from pineapple waste when compared to SFE. In addition, the optimized operating condition showed that PLE is a more sustainable technique, with less time and energy demand.

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Special Session

Poster

Solubilization of ossein-hydroxyapatite matrix from bovine rib by different acids provides antioxidant compounds – a potential source of type I collagen and calcium

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OBJECTIVE
Investigate the solubilization of bovine rib by different acids with a characterization of the ossein-hydroxyapatite matrix by nitrogen/ash contents and antioxidant capacity by DPPH and FRAP assays.

METHODS
The bovine rib was obtained in a slaughterhouse (Beltec Group, Brazil) and was prepared for solubilization. The raw rib was dried at 60 °C/24 hours (Solab SL-102, Brazil) and was ground in hammer mills (Tecnal TE-330, Brazil) and high-energy efficient mills (Retsch PM 100, Germany). The rib powder was boiled at 100 °C/60 minutes (Solab SL-155, Brazil) to remove the fat. The fat-free rib powder was incubated at 37 °C/3 hours/200 rpm (Novatecnica NT715, Brazil) according to solubilization conditions (1:10 w/v): matrix solubilized by acetic acid (1 M); matrix solubilized by acetic acid (1 M) followed by lactic acid (1 M); and matrix solubilized by acetic acid (1 M) followed by propionic acid (1 M). The solubilized matrices were characterized for nitrogen content by Kjeldahl (AOAC 955.04) and ash content by ashing (AOAC 942.05). The solubilization extracts were characterized for antioxidant capacity by DPPH and FRAP assays (Weblabor WUV-M51, Brazil). The triplicates were compared by ANOVA and Tukey test at 5% significance (Minitab, USA).

RESULTS
Rib preparation was important for the interaction of the ossein-hydroxyapatite matrix with the acid reagents. Solubilization by different acids affected the nitrogen and ash contents. Matrix solubilized by acetic acid followed by propionic acid indicated the beginning solubilization of ossein (type I collagen source) and the solubilized extract provided higher antioxidant capacity by DPPH assay. Matrix solubilized by acetic acid followed by lactic acid indicated the solubilization of hydroxyapatite (calcium source) and the solubilized extract provided higher antioxidant capacity by FRAP assay.

CONCLUSION
Solubilization of bovine rib ossein-hydroxyapatite matrix by different acids had effects on the contents and provided solubilized with antioxidant capacity. Solubilization by acetic and propionic acids shows alternative solubilization of ossein with antioxidant capacity. Solubilization by acetic and lactic acids shows alternative solubilization of hydroxyapatite with antioxidant capacity. The investigation contributes to the biotechnological potential of the bovine rib and the solubilization processes for further studies to obtain type I collagen and calcium.

Special Session

Poster

Nano-filtered acid casein whey as a potential medium for the cultivation of freshwater microalgae Tetradesmus obloquus and Chlorella vulgaris

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During the production of acid casein followed by diafiltration, a large volume of clean and clear whey permeate is generated which is rich in minerals. Due to high mineral and salt content along with low carbon content, it is difficult to utilize or treat this by-product while it still cannot be discarded untreated to the environment. Microalgae can grow without the need of carbon source while they capture atmospheric CO2 and convert it to a high value biomass, normally rich in omega-3 oil and protein. In this study, autotropic microalgae growth of freshwater microalgae Tetradesmus obliquus (TO) and Chlorella vulgaris (CV), on whey permeate was investigated. The effect of cultivation on the protein, nitrate, ammonium, and phosphate concentration of the medium was studied. Changes in cell growth pattern were also investigated by light microscopy and flowcytometry. The results showed that CV can uptake nitrate sharply while TO utilizes phosphate with higher rates. At the initial stages, all the cultivation biomass production was mainly due to cell division while at the final stages, the cells tend to grow in their size. Both flowcytometry and microscopic analysis confirmed that the largest population number was observed for CV followed by TO. Since microalgae could utilize the atmospheric CO2 as their carbon source, the wastewater streams used in this study favored the growth of microalgae. Therefore, it can be concluded the application of microalgae cells for nitrate and phosphate recovery from acid casein by-products is a promising method for wastewater treatment. The obtained biomass can be further separated for other applications such as feed or high value food to address a circular bioeconomy approach and sustainable biomass production.

Special Session

Poster

sustainability assessment of commercial aquaponics farm: a case study using life cycle assessment

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Introduction: “Abbaye farm” is commercial aquaponics exploitation located in Chaumousey, France, created in 2019. The farm's management includes a high diversity of vegetables (more than 30 species throughout the year), seasonal production, no heating of air or water, no artificial lighting, and the rearing of non-carnivorous fish species. The primary aims of this work are (i) identifying the “hot-spots” of the environmental impact of commercial-scale aquaponics systems by using the normalized LCA method; (ii) comparing the results to other LCA publications; (iii) proposing effective strategies to reduce the overall impact of the “Abbaye farm”. Method: A method-based Life Cycle Assessment (LCA) analysis was used to assess the environmental impact of “Abbaye farm”. SimaPro software was used for LCA as the modelling platform and data for the life cycle inventory were modelled for each sub-system production using this software. A comprehensive cradle-to-gate LCA using multiple midpoint environmental impact categories (such as global warming (GW), land use (LU), water dependency (WD), freshwater/marine ecotoxicity (EC) and eutrophication (EU)) was analyzed in this case study of a commercial aquaponic system. Some authors have used the LCA tool to investigate the environmental sustainability of aquaponics, and it is typically utilized on small-scale systems, research pilots, or even modelled aquaponics Results: The main contributors to the aquaponic system’s environmental impact hotspots were identified: equipment, fish feed, and electricity contributed to more than 90% of environmental impacts in all investigated categories. These values were then compared with other LCA literature studies on aquaponics, hydroponics, and aquaculture. The comparison with other aquaponics and alternative systems showed that Abbaye farm is more sustainable regarding environmental impacts. Finally, effective strategies were proposed for leading to better system management and supporting the long-term decisions on the environmental sustainability of aquaponics as a promising agri-food production system.

Special Session

Poster

Willingness to consume insect-based food in France: Determinants and consumer perspectives

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The sustainability of the current food production systems is being jeopardized due to global trends, such as urbanization, which have shifted consumption patterns towards an increased consumption of high-energy products, including meat. Considering that the livestock sector is responsible for a significant percentage of the food industry's environmental impact, the search for other novel protein sources has launched a niche sector in the meat alternative industry. Edible insects possess an attractive nutritional profile, particularly due to their protein content, and generate a low environmental impact compared to traditional meat products. However, entomophagy (consuming insects as food), is not common in western societies. As consumer acceptance is a major challenge for the adoption of entomophagy, the purpose of this study is to analyze the willingness to consume insect-based food (IBF) in France and identify the factors that prevent or encourage entomophagy. An online questionnaire consisting of 46 questions was developed and administered using Qualtrics. Subjects (n=617) were surveyed for demographics, food neophobia, food disgust sensitivity, familiarity with entomophagy, knowledge about entomophagy, exposure to IBF, entomophagy experiences, motives and barriers of entomophagy, and willingness to consume IBF. Data were analyzed by difference tests, bivariate correlations, and multiple correspondence analysis. Results suggested that consumers between 18-30 years old have more knowledge about and exposure to entomophagy and are more willing to consume IBF. Repeated exposure to entomophagy decreased food neophobia and food disgust sensitivity and increased familiarity with entomophagy, insect-eating experiences, and willingness to consume IBF. Environmental sustainability, nutritional value, and flavor are important influencers of entomophagy that can be used to develop promotional strategies for IBF products in France

Special Session

Poster

Life cycle assessment in beer industry: Current state and future prospects towards environmental sustainability

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Food production and processing industries require a variety of resources, including raw materials, energy and water, which is oftentimes depicted in severe environmental effects. Life Cycle Analysis (LCA) is an efficient framework for evaluating the environmental impacts of product systems and decision support, with its main target being the identification of hotspots during the stages of production. Beer can be considered a food product, since it is mainly produced by barley grains, and is among the most popular and widespread products worldwide. In particular, beer production requires a large amount of grains, water, and energy that result in the production of substantial quantities of solid wastes (mainly in the form of spent grains) and wastewater. Consequently, several methods have been applied for the treatment of the aforementioned wastes in order to purify the wastewater and valorize the solid wastes for the production of energy, aiming in recycling them within the industry. The main objective of the present work was to evaluate the total environmental impact of a beer industry (scenario case) that has incorporated appropriate wastewater (aerobic digesters, membrane systems etc.) and solid wastes treatment methods (anaerobic digesters) and compare it to a typical beer industry (base case) via performing LCA. For this purpose, the whole process chain within the beer industry was studied, and data inventory for both cases was performed. LCIA was conducted using Gabi ts, the selected impact assessment method was ReCiPe 2016 (H), and as functional unit, 1 ton of treated barley was selected. According to the obtained results, water recycling and energy valorization of solid wastes for energy production and usage within the beer industry resulted in an improvement in the environmental footprint, contributing towards environmental sustainability.

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Special Session

Poster

Beef chuck roast tenderization by Yoghurt acid whey marination: Process optimization, antioxidant activity and Shelf life study

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Objective

Recently, yogurt acid whey (AW) – the main by-product of strained yoghurt production – has been effectively valorized as a tenderizing agent for marinating meat products. Its high content in lactic acid and calcium may affect the texture of these products while its low pH-value may have potential antimicrobial properties resulting in extended shelf-life. The objective of this study was to optimize the beef meat (beef chuck roast) tenderness, using AW as tenderizing agent and to evaluate its effect on in vitro gastrointestinal digestion and potential shelf-life extension.

Methods

A fully kinetic study was performed in order to select the optimal marinating parameters of beef slices, such as AW concentration, meat/liquid ratio and treatment time. Optimization of marinating process was conducted via Response Surface Methodology based on the more pronounced beef tenderness achieved with AW use, after cooking (80 °C for 45 min). The effect of optimal marinating conditions on antioxidant activity after in vitro gastrointestinal digestion of samples was also evaluated. Microbial analysis, quality indices and sensory evaluation of raw and marinated beef slices were evaluated during refrigeration storage (4 °C). The shelf-life of raw and marinated beef slices was also determined.

Results

AW marination enhanced the beef tenderness at all the studied conditions. The optimal marinating conditions were: 12.5% AW, 1:1 meat/liquid ratio and 19 h treatment time, resulting in 93% decrease in beef firmness, without significantly affecting the quality and sensory characteristics of beef slices ($p<0.05$). AW-marination of beef slices increased or maintained antioxidant activity during gastrointestinal transit. Total aerobic bacteria of beef meat were significantly reduced by marinating procedure. The shelf-life of marinated beef was extended by 25% (8 days) compared to the corresponding 6 days of raw sample at 4 °C.

Conclusions

The use of AW in the meat industry could have a dual benefit: i. act as a tenderizing agent with antimicrobial effects and ii. provide an effective way for AW valorization, leading to reduced risks related to its disposal.

Special Session

Poster

Study of the Amazon yam to obtain sustainable food products with higher added value

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In line with the concepts of zero hunger, poverty eradication and sustainable agriculture, this work studied new sources of nutrients that can improve people's health through actions aimed at the consumption of regional Amazonian products. The yam of the Dioscorea species has the potential to act as an agent of socioeconomic transformation through practical applications that respect family farming and value the local culture. This species is native to Brazil and occurs in tropical and subtropical regions. Despite its great socioeconomic importance in poor countries, it lacks scientific studies and incentives to expand development, as there is no developed processing chain and, as a result, it ends up losing a considerable part of production due to the only form of commercialization (in natura). The objective of this work was to study the white and purple yams produced in the city of Caapiranga/AM/Brazil, aiming at their greater food use. Samples were evaluated for nutrient chemical composition using official AOAC methods; later, they were subjected to processes for the flour production, aiming to make them more stable and, as a consequence, contribute to their consumption in a safer way. The use of these flours as an ingredient for food application in gluten-free and clean label cookies was also studied, privileging formulations without additives, which were submitted to the sensory acceptance test. The results of the physical-chemical characterization indicated that the yams studied have potential for human consumption. They are good sources of energy, since they have more than 80% of carbohydrates and high fiber content, which is very beneficial for health. In addition, as they are gluten-free, they can serve the healthy product market and the celiac public. Therefore, white and purple yam flour can be an alternative to reduce post-harvest losses, giving stability to the product and adding value. More research needs to be carried out to better understand the nutritional benefits of yam flours, especially with regard to the content of minerals and phenolic compounds. Taking into account that flavor and texture characteristics are decisive for the acceptance of the product, the cookies produced in this work showed good acceptance.

Special Session

Poster

Fighting Shelflation: Reduction of Food Loss at Consumer Level by Chemometric Characterization and Predictive Modelling of Organoleptic Quality Loss Throughout the Food Distribution System.

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Almost 40% of all the food produced in Canada become food lost and waste (FLW). 60% of this is attributed to the consumer. Almost half of FLW by consumers is fruit and vegetables. Recently, a decrease of the shelf life of produces is being reported by consumers, to the point of being coined “shelflation” in the media.

The quality of fruits and vegetables is never better than at the previous stage of its journey: the actions upstream have consequences on all the stages downstream. In this context, it is important to study the "propagation" of this degradation rather than putting the blame of the end user.

The journey of food through the value chain and the local, national and international distribution network is complex. It includes multiple interrelated stakeholders, covers great distances to reach remote and indigenous communities, suffer from large temperature differences (-30 °C to +35 °C for ground transport in Canada alone). Fruits and vegetables are greatly affected by those conditions. Several solutions aimed at limiting FLW are implemented throughout the value chain, but they have limited effect of the end-user shelf life as they are primarily aimed at increasing profitability for the actor implementing them. We therefore propose a global approach, aiming to quantify the impacts of the various actions throughout the food system in order to reduce FLW.

Numerous research articles on a number of fruits and vegetables report how hyperspectral imaging (HSI) technology can predict organoleptic quality through the use of chemometrics algorithms. This allows the development of methods aimed at the food industry. Using HIS and statistical algorithm (AI), we are able to describe, diagnose, predict the quality of the produces and prescribe appropriate actions. Representative examples of such approach are presented.

Special Session

Poster

Revealing the potential of Brewer's Spent Grains In Human Nutrition: Exploration of Protein Extraction Performance and Functional Properties

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One of the main ways of reducing the environmental costs of the brewing industry is to find new ways to increase the value of brewer's spent grain (BSG), the main organic waste associated with beer production. Currently, most of this by-product is relegated to animal feed or landfills but it could have other potential uses with higher economical value such as human consumption. Of the two main constituents of BSG (protein and fiber), its protein content is of particular interest for human consumption. To investigate BSG proteins and identify potential food applications, native BSG, alkaline extract and alkaline extract with L-cysteine as a reducing agent were compared for a wide range of functional properties.

BSG proteins were extracted using NaOH with and without L-cysteine as a reducing agent. Composition (protein, lipid, moisture, carbohydrate, and ash content) of extracts and native BSG was determined. Protein content was further investigated and characterized using SDS-Page and circular dichroism. Emulsifying power, stability, and capacity, foaming capacity and stability, viscosity and solubility were investigated for each extract and native BSG at pH 2, 4, 6 and 8. Water holding capacity, gelling properties and hygroscopicity were also investigated.

Both methods of protein extraction yielded extracts with higher protein content and improved functional properties when compared with native BSG in all tested parameters. Extractions with reducing agent (L-Cysteine) doubled protein content (from 20 to 40 %). Native BSG showed almost no emulsifying and foaming properties while both types of extracts yielded results on par with similar data from other studies on casein and pea proteins. In all cases, functional properties were improved in higher pH conditions (pH 6 and 8) and were lowest at pH 4 where isoelectric precipitation of proteins was observed.
BSG proteins have interesting potential applications in human consumption especially regarding their emulsifying and foaming properties however, future food applications should focus on low acid foods to maximise BSG protein solubility and other functional properties.

Special Session

Poster

Ultrasonically modified enzyme activity, antioxidant capacity and physicochemical properties of cereal brans and their application in flat bread production

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Oat and barley bran are rich in β-glucan and are a good source of minerals and polyphenols. The presence of endogenous β-glucanase leads to a significant reduction in the molecular weight of β-glucan and, consequently, its physiological effects. The challenge is to minimize the degradation of β-glucan while maximize the reduction of phytates which obstruct the mineral bioavailability. Ultrasound, as an environmentally friendly and non-toxic food processing technology, is increasingly being used to modify enzyme activity, functional and rheological properties of foods. The aim of this work was to investigate the influence of high intensity ultrasound (24 kHz, 400 W, 100% amplitude) treatment at three specific energies (87, 217.5, and 348 J/g) with or without pulse mode of oat and barley bran. The β-glucanase and phytase activity, concentration of phenolics and phytates, antioxidant capacity, hydration and rheological properties of cereal brans were assessed. Ultrasonic treatment with higher specific energy and temperature significantly decreased the activity of β-glucanase and phytase in both bran types. In addition, longer treatment (i.e., higher energy and temperature) significantly decreased antioxidant capacity (DPPH), total phenolics, and phytate concentration. Ultrasonic treatment increased water swelling capacity (WSC) and water retention capacity (WRC) and changed the dynamic viscoelastic characteristics of cereal bran. Treatment at 217.5 J/g without pulse mode resulted in the best desirable parameters for oat bran with 69.2% inactivation of β-glucanase activity and 17.4% phytate reduction. For barley bran, it was 348 J/g in pulse mode with 35.6% β-glucanase activity and 38.7% phytate reduction. The addition (10 % of flour mass) of oat and barley bran did not significantly affect the physical properties of flat bread, except for its hardness and chewiness. This study suggests that ultrasound, as an energy-saving technique, has the potential to alter enzyme activity, bioactive compounds, antinutrients and functional properties of cereal bran for their application in bakery products.

Special Session

Poster

Edible coating formulated with essential oregano oil for its application in strawberries and determination of the degree of inhibition of fungus Botrytis cinerea.

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According to the Colombian Ministry of Agriculture, for the year 2020, strawberry production was 86,500 tons per year, with a yield of 43 tons/ha. Strawberry is a crop from which peasant families live throughout the national territory, approximately 2,000. However, fresh-marketed strawberries have a short shelf life of 3 to 5 days due to factors of poor post-harvest practices and attack of microorganisms, being the attack by Botrytis Cinerea is the principal generator of losses, for which it is of great importance to find alternatives for the control of the fungus and in this way achieve a greater shelf life of the strawberry. The objective of this study was to evaluate the inhibitory effect of an edible coating made from whey protein, cassava starch, and oregano essential oil (AE) on the growth of the fungus Botrytis Cinerea. The methodology included formulating two solutions: one of protein and the other of starch at (m/v). Subsequently, they were mixed at a ratio of (1/1) m/m with ultra-turrax at a speed of 1600 rpm for 2 minutes; the amounts of protein and starch used were 2.5 and 5%, respectively. Later, different percentages of oregano essential oil (0.05%, 0.1% and 0.15%) were added. To determine the inhibition of the Botrytis Cinerea fungus, the growth ring was measured in a Petri dish. The percentage of inhibition of Botrytis Cinerea was 85% and 90% for the percentages of EA addition of 0.1% and 0.15%, respectively. Concerning the application in strawberries, it has been possible to determine that the edible coating has managed to increase the shelf life of the strawberry by nine days at refrigeration conditions of 4±0.2oC. In general, it can be concluded that it is possible to formulate an edible coating with cassava starch, whey protein, and essential oil of oregano to inhibit the growth of the fungus Botrytis cinerea, which has the potential to be applied to strawberries, to increase the yield shelf life of the same and therefore improve both the Colombian and international markets.

Special Session

Poster

Producing Mono-glyceride from Poultry Slaughterhouse Fat Waste

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There is increasing interest in manufacturing value added products from different slaughterhouse waste and byproducts. One of these materials is abdominal fat waste. According to the usual practice, the fat is separated from the containing tissue using heat through hot water and some alkaline agents. The current end use of the obtained fat is for soap making and animal feed supplement. In this research a different approach was applied and kind of texturing product containing a mixture of mono-, di-, and tri-glyceride was produced by reacting the extracted fat with glycerin.
Results: The extracted fat samples from the poultry slaughterhouse through three different methods were successfully converted to an emulsifier mixture containing mono-, di- and triglyceride agents.
Conclusion: Considering the vast application areas of emulsifiers including mono-glyceride and di-glycerides, obtaining a fat mixture containing these agents means turning a usual food industry waste or by-product into a product whose values and applications are a lot more expanded.

Special Session

Poster

Application of biopolymers-based solutions incorporated with emulsified bioactive compounds as coating of synthetic polymers films: a review

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Application of biopolymers-based solutions incorporated with emulsified bioactive compounds as coating of synthetic polymers films: a review

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ABSTRACT

Synthetic polymers are excellent food packaging materials due to their low cost, high flexibility, ease of processing and good physical properties. However, the incorporation of active compounds during the production of synthetic polymeric films can degrade their functionality due to the high temperatures applied. For this reason, an approach was adapted that combines synthetic materials with other biopolymers (carriers of active compounds) to obtain an additional function of conventional packaging. However, a large percentage of biopolymer matrices are hydrophilic, a characteristic that makes it difficult to incorporate hydrophobic bioactive compounds, limiting the development of active films. Thus, to solve this problem, the method of encapsulation of bioactive compounds in Pickering emulsions was recently studied for the preparation of a film-forming solution. Thus, this review aims to present and discuss recent researches on the development of bilayer films produced with coatings based on biopolymer film-forming solution incorporated with bioactive compost (encapsulated into Pickering emulsion) for biodegradable and non-biodegradable synthetic polymers films. The focus will be in the effect of coating on the main physical and functional properties of the bilayer film. This review can be used in further studies for the application of bilayer films and thus allowing to guarantee quality and prolong the shelf life of the foods.

Keywords: Synthetic polymers, food packaging, bioactive compounds, bilayer films.
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Special Session

Poster

Husbandry and management of a frog farming pilot facility

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Every year, Europeans consume approximately 4500 tons of frog legs, with most of the demand coming from France. However, less than 10 tons are produced yearly in European frog farms due to legislative restrictions on the commercial exploitation of native species, so the remaining bulk of the demand is met by importing frozen frog legs from Asian countries, where animals are still sourced directly from the wild with little regard for their welfare by the millions. To protect and improve wild frog populations in source markets, the EU should strive to implement sustainability measures which allow for native frog farming operations. Therefore, it is imperative to continue researching on husbandry and management systems to gather data which could influence policy decision-makers. The main objective of this work was to develop a frog farming pilot facility (15 m2), combined with a digital platform to improve production-based decision making. The project consists of assembling an entire production unit in the context of production activity. We focused on the native Iberian water frog (Pelophylax perezi) to obtain biometric data to support the digital platform's development. Such tools could improve future research in this area, facilitating the study of, for example, the effects of different dietary regimes or population densities on growth rates. Testing facilities like these also help to overcome challenges that would be difficult on industrial scales.