Novel technology in high moisture extrusion for customized and controlled plant protein-based meat alternatives production

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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.