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.