
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' , $\tan\delta$ and γ 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 $\tan\delta$, was only slightly affected by the protein concentration, while both the G' and γ 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' , γ and K counteracted the importance of n and $\tan\delta$, 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.