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.