**Understanding the structuring behaviour of plant-based proteins during extrusion using high-temperature shear cell and near-infrared spectroscopy**

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Plant-based meat analogues can be used to stimulate the consumption of plant-based proteins instead of animal proteins, which has beneficial environmental and health effects. High-moisture extrusion (HME) is commonly used to produce these meat analogues with a fibrous structure resembling that of meat. Even though this technique has been used since the 1980s, the mechanism behind the fibrous structure formation remains unclear, making process and quality control challenging. One of the main reasons for this is the ingredient properties, as well as the processing parameters can affect the product quality and the influences of these parameters are strongly interrelated. Therefore, this research aimed at developing methods to disentangle the effects of the processing parameters during the different processing steps of HME on the fibrous structure formation. To do so we used a high-temperature shear cell (HTSC) to study the different processing steps during HME: 1) mixing and hydrating, 2) thermomechanical treatment, and 3) cooling. HTSC processing consists of the same unit operations as extrusion, but allows individual control over the various processing parameters, such as deformation rate, processing temperature and residence time.

Our results show that mixing affects the final product structure but that this effect was influenced by the ingredient formulation and was different for soy protein concentrate, soy protein isolate-wheat gluten and pea protein isolate-wheat gluten products. Additionally, the application of shear during cooling in the HTSC showed that the shear stresses in the cooling die is not a prerequisite for fibrous structure formation from pea protein isolate-wheat gluten mixtures. To measure the overall intensity of the thermomechanical treatment we developed a new parameter, “equivalent shear-cell-temperature”, by combining the HTSC and near-infrared (NIR) spectroscopy. This parameter can be used to quantify the effects of barrel temperature, screw configuration and screw speed on the thermal process intensity and final product structure. We also applied NIR spectroscopy to measure the composition of meat-analogue like systems containing oil. In conclusion, the application of HTSC and NIR spectroscopy to study structuring in the HME can give valuable insights in the structure formation mechanism during HME and can thus enable developments towards more efficient processing of meat analogues with better textural properties.