Extrusion simulation for the design of fibre-rich breakfast cereals

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Many starch-based foods, such as texturized ingredients, breakfast cereals, snacks, crackers, pasta, noodles, and many others, are produced by twin-screw extrusion. Despite significant progress in process modelling, the design of extruded products at the industrial level is still based on a trial-and-error approach. The main challenge is determining the viscous behaviour of melts under extrusion-like conditions that require specific rheometers. The 1D global model of twin-screw extrusion Ludovic© has been widely used for the design of experiments of processing, but essentially for simple formulations: maize and wheat starches and wheat flour. Its use in product design has never been tackled before. Then, the work's goal is to test whether this model, implemented with an appropriate viscosity law, can be deployed as a prototype of a computer-aided tool for predicting various properties of fibre-rich extruded breakfast cereals from extrusion operating conditions.

Various food models were selected: blends of wheat flour and wheat bran with bran content up to 26 wt%. A large data set was built from literature data, including foods' properties and extrusion variables (temperature T and specific mechanical energy SME). The foods features were hydro-solubility of starch (WSIstarch), macrostructure described by radial expansion index (SEI) and cellular structure expressed as cell density per cm^3 (NC). Twin-screw extrusion processing was simulated using the 1D global extrusion model Ludovic© (Sciences Computers Consultants, France). The extruder operating charts representing predicted extrusion variables as function of operating parameters were built. From the correlations between predicted extrusion variables (T, SME, melt viscosity ?_com) and product features (WSIstarch, SEI, NC), a set of extrusion variables to obtain a product with desired properties can be targeted. Thereafter, the feasible region of operating conditions can be determined from extruder operating charts.

As a future prospect, extrusion simulation will be applied to the design of a wide range of extruded starch-protein blends from pulse crops, including meat analogues. Besides classical structural and functional properties, the textural and nutritional features will be tackled.