Effect of morphological features on the mechanical properties of extruded pea snacks: finite element modelling

GUESSASMA S. (1), JEBALIA I. (1), KRISTIAWAN M. (1), DELLA VALLE G. (1)
1 INRAE, Nantes, France

Extruded foods from pulses can be envisaged as solid foams with cell walls are considered as a dense starch-protein composites. Pea flour (PF) and blends of pea starch and pea protein isolate (PPI) with different protein contents (0.5-88% dry basis) were extruded to obtain models of dense starch-protein composites. Their morphology was revealed by CLSM microscopy, and their mechanical properties were investigated using a three-point bending test complemented by Finite Element Method (FEM) modelling. Composite morphology revealed protein aggregates dispersed in the starch matrix. It was described by a starch-protein interface index Ii computed from the measured total area and perimeter of protein aggregates. The mechanical test showed that the extruded PF and PPI ruptured in the elastic domain, while the extruded starch-PPI (SP) blends ruptured in the plasticity domain. The mechanical properties of pea composites were weakened by increasing the particle volume fractions, including proteins and fibres, probably due to the poor adhesion between starch and the other constituents. The mechanical behaviour of pea composites did not accurately follow simple mixing laws because of their morphological heterogeneity. Modelling results show that the elastoplastic constitutive model using the Voce plasticity model satisfactorily described the hardening behaviour of SP blend composites. Reasonable agreement (2-10%) was found between the experimental and modelling approaches for most materials. The computed Young’s modulus (1.3–2.5 GPa) and saturation flow stress (20-45 MPa) increased with increasing Ii (0.7-3.1), reflecting the increase of interfacial stiffening with the increase of contact area between starch and proteins. FEM modelling was shown to be a relevant approach to consider the microstructure heterogeneity of starch-protein composites.