**Plant Proteins and Their Non-Protein Components: Understanding Their Interplay with Different Starch Types during Hydrothermal Processing**

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The transition from animal-based proteins to plant-based alternatives is essential to address environmental concerns and promote more sustainable food systems. However, when incorporated into carbohydrate-based foods, plant proteins may compete for the available water and alter the phase transitions of the involved biopolymers, affecting network formation and technological properties of derived foods. This study investigates the interplay between plant proteins and starch, key biopolymer in the human diet, during hydrothermal processing, aiming to provide insights about the mechanisms of such interactions for designing plant-based systems with enhanced functionality. Protein concentrates (50-53% protein) from sunflower, a by-product of oilseed extraction, and from lupin, a protein-rich legume with high fibre content, along with their purified protein isolates (80-90% protein), were used, possessing different native states and 11S/7S subunit ratios, with sunflower protein predominantly consisting of 11S and lupin containing both globulins, but with a higher proportion of 7S subunits. The proteins were extensively characterized in terms of molecular weight, globulin/albumin fractions, secondary structure, gelation and thermal properties, solubility and surface charge to establish structure-function relationships. To explore protein-starch interactions, wheat and potato starches were chosen due to their different molecular architectures and swelling kinetics. Protein-starch mixes were processed under high moisture, high temperature and low shear conditions with a 25% protein addition to the starch-based matrix. The resulting gel matrices were characterized in terms of microstructure, oscillatory rheology, retrogradation propensity, and water distribution (LF-NMR). Differences in network formation were observed in the mixed matrices depending on the protein source and its purity. Interestingly, protein isolates delayed starch swelling during early stage of hydrothermal processing, probably due to water competition needed for protein denaturation. Microstructural results showed phase separation and protein-rich domains in mixes with sunflower, likely due to the higher proportion of gel-forming 11S globulins, which hinder dispersion in the starch matrix because of their hydrophobic nature and disulfide bonds, in contrast to lupin’s 7S globulins, more hydrophilic and with a more homogeneous distribution. Interestingly, all protein ingredients reduced the extent of starch retrogradation, likely due to spatial restriction and increased water-holding capacity, which may hinder cross-linking of starch molecules and moisture redistribution within the gel. Moreover, lupin protein, especially its concentrate due to the presence of fiber, was particularly effective in reducing free water and increasing weakly bound water within the mixed systems. Rheological analyses suggested that starch-starch interactions were the primary drivers of storage modulus (G’) development, as shown by the higher G’ of the starch control with the same solids content as the protein-starch mixes. However, protein-starch mixes exhibited different rheological behaviors based on the starch source. In potato starch mixes, lupin addition led to a higher G’ than sunflower, whereas in wheat starch mixes, sunflower addition resulted in a higher G’ than lupin proteins, regardless of its purity. All protein mixes increased tan(δ) compared to the control, resulting in a weaker viscoelastic gel. These results underscore the importance of considering the interplay of various interactions, including protein-protein, protein-starch, starch-water, and protein-water, which influence gel viscoelastic behavior. These findings advance the understanding of biopolymer interactions influencing food structuring during hydrothermal cooking and highlight the importance of protein intrinsic characteristics for optimizing the incorporation of sustainable plant proteins in food applications.