Influence of nanocellulose with different particle size on pasting and rheological properties of wheat starch

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Tailored design of novel materials requires a huge understanding about structural properties, and how structures define functionality. Cellulose nanofibrils (CNF) and cellulose nanocrystals (CNC) have been described as biomaterials with wide applications in polymer science. However, their use in food science and nutrition, specifically designing food structures is scarce. This work aimed to investigate how CNF and CNC modify macrostructural features of wheat starch such as pasting and rheological properties.

CNF (Vuelo Pharma, Brazil) and CNC (UPC-UMaine, USA) were blended with wheat starch (Sigma-Aldrich, Germany). CNF and CNC were added at concentrations up to 10%w/w. Starch-CNF and starch-CNC blends were processed by Rapid-Visco-Analysis (RVA, 90°C/3min) and cooled to 25°C. Pasting parameters were assessed. After RVA, starch-nanocellulose pastes were characterized by rheology (25°C): dynamic frequency sweep (0.1-600rad/s), dynamic time sweep (4h) and in-shear recovery (100 1/s, 60s).

Previous analysis (AFM and DLS) allowed to assess particle size (120nm CNC, 4000nm CNF) and charge (-49mV CNC, 1.3mV CNF). Nanocellulose significantly modified the pasting properties, but strongly influenced by particle size. CNF significantly increased all pasting parameters of wheat paste, whereas CNC only slightly increased same parameters (e.g. final viscosity 1700cP, 2000cP and 4700cP in control starch, 10%CNC-starch and 10%CNF-starch, respectively). Rheology characterization showed that CNC and CNF produced a significant increase in G’, which was also proportional to nanocellulose concentration. However, values of loss factor (G’’/G’) suggest big structural differences addressed by particle size of nanocellulose. Loss factor values were lower in pastes CNC-starch, over the whole frequency range tested. The latter was confirmed by dynamic time sweep, which showed that CNC promoted the self-association of amylose detected from the faster increase in G’ and faster decrease in loss factor, which in turn approaches rapidly to values <0.1 depicting behavior as strong gels. The opposite was observed in CNF-starch, where G’ were lower than control in samples containing CNF. Loss factor of gels containing CNF reached values >0.1 depicting behavior as weak gels. Interestingly, in-shear recovery data showed that strong gels promoted by CNC has lower capacity of recovery with values around 57-62%, whilst weak gels containing CNF showed values of 80-67%.