Dual modification of cassava starch by reactive extrusion technique: effects of operating conditions and phosphorylated/cross-linked agents on physico-chemical properties, pasting characteristics and freeze-thaw stability of starch

Abstract:

Reactive extrusion (REX) was proposed as a means of modifying the functionalities of cassava starch through cross-linking using a pilot-scale, co-rotating twin screw extruder. Cassava starch was blended with sodium trimetaphosphate (STMP) and extruded at a constant feed rate of 5.3 kg/h, a reaction temperature of 40°C and a screw speed of 200 rpm. Response surface methodology was used to evaluate the effects of moisture content (50-85% of dry weight starch), NaOH concentration (0.05-0.1M) and STMP level (0.5-2.0% of dry weight starch) on the degree of substitution (DS), degree of cross-linking and pasting properties, as well as the water solubility index (WSI) and swelling power of cross-linked starch. Regression analysis showed that the DS of cross-linked cassava starch was affected significantly (P<0.05) in linear terms, while the degree of cross-linking and pasting properties were affected significantly (P<0.05) in linear, interaction, and quadratic terms. DS varied from 0.0038 to 0.0149 and increased as the moisture content decreased. Introduction of phosphate cross-links into the starch restricted the mobility of the molecular structure, leading to a reduction in WSI and viscosities of starch. Starch became slightly yellowish with an increase in NaOH concentration. Starches with a degree of cross-linking between 51-56% yielded the highest peak viscosity (2197-2448 cP), final viscosity (3185-3422 cP) and swelling power (8.03-8.45). Cross-linking reaction through REX altered the crystalline patterns of

cassava starch. Subsequently, cross-linked starch with three different degree of cross-linking; 1) low degree of cross-linking (50-69%); 2) medium degree of cross-linking (70-89%); and 3) high degree of cross-linking (>90%). Physical properties (water solubility and swelling power), pasting properties, gel properties and freeze-thaw stability of cross-linked cassava starch samples were studied in comparison with those of extruded starch control (non-cross-linked) and native cassava starch samples. The results indicated that the clarity and peak viscosity of starch decreased with an increase in degree of cross-linking. Cross-linking reduced the water solubility index and swelling power of starch. Extruded starch controls and all cross-linked cassava starch samples showed higher swelling power at 30 °C than the native cassava starch. At 80 °C, the swelling power of all cross-linked cassava starch samples was similar to the native starch but higher than the starch control equivalents. The maximum peak and final viscosities were shown in lowest degree of cross-linking. Gels made from cross-linked starch samples showed greater strength and stability against freeze-thaw process compared to the native starch. Cross-linked cassava starches with different degrees of cross-linking and functionalities were developed successfully using a pilot-scale REX, which could be utilized as food and non-food additives.

Keywords : Cassava starch/ Cross-linking/ Pilot-scale/ Reactive Extrusion/Physico-chemical properties