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Effect of granular characteristics on pasting properties of starch blends

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ABSTRACT

Pasting and morphology properties of starch blends composed of waxy (waxy rice and waxy corn) and non-waxy (normal corn, tapioca and potato) starches at various ratios were investigated for elucidating effect of granular characteristics on pasting of blends. Pasting profiles of blends were between those of the component starches alone, while the changes varied with starch source. Results reveal obvious water competition during pasting for blends composed of waxy starch and highly swelling non-waxy (tapioca or potato) starch. On the contrary, starch blends composed of waxy starch and non-waxy (normal corn) starch with restricted swelling showed less water competition during pasting, and the pasting attributes could be estimated from those of the component starches following the mixing ratio. Results indicate that the pasting properties of starch blends composed of waxy and non-waxy starches depend on not only the mixing ratio, but also the granular characteristics of component starch.

1. Introduction

Native starch does not meet industrial needs for a wide range of application purposes, but can be physically or chemically modified to obtain desired properties. Generally, chemical modification, such as cross-linking and/or acetylation, is more effective and widely used (Jacobs & Delcour, 1998). However, for healthy standpoint, nowadays market's tendency presses the producers toward more natural food components and avoids as much as possible the chemical treatments. It is therefore of interest to find new ways to improve the properties of native starches without chemically modified. One possibility is the mixing of starches with different botanical sources (Ortega-Ojeda & Eliasson, 2001), which had been proposed to use in the mixtures of pudding powder (Stute & Kern, 1994). Sandhu, Kaur, and Mukesh (2010) indicated blending of potato and rice starch in the ratio of 50:50 resulted in good quality noodles as compared to noodles prepared by using of starch with other blending ratios, in terms of their lower cooking time, higher cooked weight, transparency and slipperiness. A 70:30 blend of the pigeon pea and rice starches produced noodles with superior quality as compared to native pigeon pea and rice starch noodles (Yadav, Yadav & Kumar, 2011).

Pasting properties of starch is generally determined by using of Brabender viscoamylography, rapid viscous analysis, or dynamic rheometry, and is useful information for understanding the textural change or retrogradation potency of the applied products. Pasting parameters of starch slurry during heating have been proposed to be related to the granule size (Okechukwu & Rao, 1995), properties of swelling power/solubility (Evans & Lips, 1992), or properties of the swollen granules and soluble materials of starch (Doublier, Llamas & Le Meur, 1987). In summary, swelling of starch is mainly a property of amylopectin, while amylose acts as a diluent.

Properties of blended starches have been proposed to be associated with starch concentration (Liu & Lelievre, 1992), mixing ratio (Chen, Lai & Lii, 2003), amylose/amylopectin ratio (Ortega-Ojeda, Larsson, & Eliasson 2004) and interactions between the granules (Obanni & BeMiller, 1997). Sasaki, Yasui, Matsuki and Satake (2002) studied starches with various amylose content by blending starches isolated from waxy and non-waxy wheat at different ratios and indicated that mixed starches showed higher swelling power than native starches with the same amylose content. Puncha-arnon, Pathipanawat, Puttanlek, Rungsardthong and Uttapap (2008) indicated that swelling capability of canna–rice starch blends decreased with increasing ratio of rice starch content at 70 °C, especially at the ratio of canna to rice starch at 25:75. At the same heating temperature, canna starch granules in the starch blends were obviously less swelled as compared to canna starch alone, this was attributed to the effect of surrounding rice starch granules on gelatinization behavior of canna starch.

Obanni and BeMiller (1997) indicated that the amylogram of starch blend, preparing by mixing common com starch (CCS) and waxy com starch (WCS) at 50:50 ratio, showed two maximum peak viscosities (PV) with the first peak slightly preceding that given by WCS alone and the second peak at the position where CCS

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reached its maximum viscosity when pasted alone. Sandhu et al. (2010) showed PV significantly increased with increasing content of potato starch in potato–rice blends, which was attributed to the higher swelling power of potato starch. Ortega-Ojeda et al. (2004) indicated that when native potato starch was added to high amylopectin potato starch, higher moduli values of starch gels were obtained and could be referred to the presence of amylose in the blends, which led to stronger network formation. This indicates that the existence of amylose is important for the rheological properties in a starch blend of native amylopectin. Obanni and BeMiller (1997) concluded that interactions of starch molecules from different starches occurred very early in the heating process, which could be between leached amylose from one starch and granules of the other starch or between molecules on the outer surfaces of granules of the two starches.

Chen et al. (2003) indicated that the gelatinization thermal properties of rice starch blends were related to the swelling power of component rice starches, and the viscosity of starch blends were determined by the different in swelling ability between the two rice starch species and the resultant shear-induced granular disintegration. Furthermore, influence of granular properties on pasting behaviors of starch blends was higher than that of the soluble materials, implying that the granular characteristics of starch granules plays an important role on pasting properties of starch blends. Although Chen et al. (2003) had proposed the granular characteristic effect on properties of rice starch blends, results were limited due to the restricted variation in properties of component starches, such as granule size or swelling behavior of rice starch used in their study. More supplementary information on other commercially available starch samples, such as corn, tapioca and potato starches, is needed for further understanding granular characteristic effect on properties and application of starch blends. In this study, pasting properties of starch blends composed of waxy (waxy rice and waxy corn) starches and non-waxy (normal corn, tapioca and potato) starches at various ratios, as well as morphology of pastes of starch blends after heated to the desired temperatures, were investigated for systematically illustrating effects of mixing ratio and granular characteristics of component starch on pasting of starch blends. The observed composition-property relationship of mixed starch systems is expected of highly industrial application feasibility.

2. Materials and methods

2.1. Starches and starch blends

Waxy rice starch was isolated from TCW70 waxy rice according to the alkaline steeping method of Lin, Wang and Chang (2008). Waxy corn starch was product of National Starch and Chemical Company (Bridgewater, USA). Tapioca starch was gifted from Vedan Enterprise Corp. (Dong Nai, Vietnam). Corn and potato starches were purchased from Roquette Company (Lestrem, France) and Parachem Company (Brande, Denmark), respectively. Starch blends were prepared by mixing waxy (waxy rice and waxy corn) and non-waxy (normal corn, tapioca and potato) starches at various ratios (90:10 to 10:90) following the procedure of Obanni and BeMiller (1997).

2.2. Granule size

Average granule size of starch was determined by a dynamic laser-light scattering-based particle size analyzer (Mastersizer Micro, Malvern Instruments, Malvern, UK) with 10–15% for obscuration and 1950 rpm for paddle speed.

2.3. Amylose content

Amylose content of starch was calculated from iodine affinity value according to the method proposed by BeMiller (1964). Starch was defatted with 85% methanol in a Soxhlet extractor for 48 h. Defatted starch (0.1 g) was suspended with 1 mL of water. Twenty milliliters of 1 N KOH was added, and the sample was dispersed by stirring at 4 °C for 30 min. This solution was then diluted with 20 mL of water. Ten mL of the solution was added 75 mL of water, 10 mL of 1 N HCl and 5 mL of 0.4 N KI by stirring in water bath at 25 °C. The iodine affinity of starch was determined by amperometric titration method using titrator (702 SM Titrino, Metrohm, Herisau, Switzerland) equipped with a platinum electrode.

2.4. Swelling power and solubility

Starch (0.1 g, db) was heated in 40 mL of distilled water to the desired temperatures for 30 min. The formation of lump was prevented by continuously stirring. The mixture was centrifuged at 4000 × *g* for 15 min. The sediment was weighed immediately and an aliquot of supernatant was evaporated at 130 °C and weighed. Swelling power and solubility of starch were measured at four different temperatures of 60, 70, 80 and 90 °C. Solubility is the ratio of the weight of the dried supernatant to the initial weight of the dry starch, while the swelling power of starch is the ratio of the weight of sediment paste to initial weight of the dry starch (Lin, Pan, Hsu, Singh & Chang, 2012).

2.5. Pasting properties

Pasting properties of starch blends were determined by using of a Rapid Visco-Analyzer (RVA 3D+, Newport Scientific, Warriewood, Australia). Each starch suspension (7%, w/w, 28 g total weight) was equilibrated at 35 °C for 1.5 min, heated to 95 °C at a rate of 6 °C/min, maintained at 95 °C for 5 min, then cooled to 35 °C at a rate of 6 °C/min, and maintained at 35 °C for 5 min. Paddle speed was set at 960 rpm for the first 10 s and then 160 rpm for the rest of the analysis (Chang, Lin & Chen, 2006). The parameters recorded were peak viscosity (PV), hot paste viscosity (HPV) (minimum viscosity at 95 °C), final viscosity (FV), breakdown (BD = PV − HPV), and setback (SB = FV − HPV). Breakdown ratio (BDr) and setback ratio (SBr) were defined as the ratios of BD to PV and SB to HPV, respectively.

2.6. Gelatinization thermal properties

Gelatinization thermal properties of starch blends were determined by using of a differential scanning calorimeter (DSC, Micro DSC VII, Setaram, France). Starch sample (about 150 mg, dry basis) was weighed in the sample pan, mixed with distilled water (starch:water = 1:3), sealed and equilibrated at room temperature for 1 h. The samples were heated from 25 to 115 °C at a heating rate of 1.2 °C/min.

2.7. Microscopic observation

Starch paste (7%, db) was heated to the desired temperatures (60, 70, 80 and 90 °C) in the RVA with the same heating rate and stirring speed used for pasting properties determination. After heating, appropriate amount of sample was loaded on slide and stained by iodine solution (1 mL solution containing 1.67 mg I_2 and 3.33 mg KI). The slide was then observed under the light microscope (BH2, Olympus, Japan).