FOOD HYDROCOLLOIDS

Pasting and rheological properties of native and anionic tapioca starches as modified by guar gum and xanthan gum

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Abstract

Effects of guar and xanthan gums on pasting and rheological properties of native and anionic tapioca starches were studied by using a Rapid Visco-Analyzer (RVA), a differential scanning calorimeter (DSC), a scanning electron microscope (SEM), and a rheometer. Results of RVA measurement indicated that addition of gums increased peak, breakdown, and final viscosities of native tapioca starch. This effect was more pronounced for guar gum than xanthan gum. Setback viscosity was increased by guar gum, but xanthan gum showed the opposite effect. For anionic tapioca starch, addition of guar gum gave similar results whereas xanthan exhibited opposite results. Pasting temperatures of all samples with added gums increased in comparison with the controls which are in good agreement with the increments of the onset (T_o) and peak (T_p) gelatinization temperatures determined by the DSC. Reduction of gelatinization enthalpy (ΔH) with gums addition was also observed by the DSC. SEM micrographs reveal that only xanthan totally wrapped the native starch granules whereas the other starch-gum mixtures, gums did not wrap the granules. Measurement of swelling power (SP) demonstrated that the anionic starch exhibited higher SP than the native starch and addition of gums appeared to increase the SP values of the mixtures at high temperatures ($>80\,°C$). Results of dynamic viscoelasticity measurement indicated that addition of gums increased the G' values two-fold at all frequencies tested, but the ratio G''/G' (tan δ) was decreased. This suggests that the starch-gum pastes behaved more solid-like characteristics than the starch alone pastes.
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1. Introduction

Tapioca starch (*Manihot Esculenta* Crantz.) is used in numerous industrial and food applications, including as a thickening and gelling agent and an adhesive for paper. However, its price in the world market is low when compared to other starch. These starches are chemically modified to obtain the better properties demanded by the industry. The chemical reagent used, however, will be banned in the health-conscious period.

Many investigations have been reported that hydrocolloids (gums) can alter the gelatinization and rheological characteristics of starches. Traditionally, gums are widely used in the starch containing food, especially guar gum and xanthan gum. These gums exhibit many functions to control rheological and textural properties of foods, to improve moisture retention, and to maintain overall product quality (Funami, Kataoka, Omoto, Goto, Asai, & Nishinari, 2005). Process such as baking of bread and cakes, extrusion of cereal based products, thickening and gelling of sauces and pie fillings are all dependent on starch gelatinization during industrial utilization (Biliaderis, Maurice, & Vose, 1980). During gelatinization, starch granules undergo hydration (derived from water during heating), swelling (irreversible), exudation of amylose and amylopectin, lose of birefringence, and alteration in viscosity (Li, Vasanthan, Hoover, & Rossnagel, 2004).

Even though the existing information about starch-hydrocolloid systems, there are still unknown aspects because of the complexity of such systems. Furthermore, according to the information reported in the literature, there are many contradictory aspects, while the correlation of these properties to real food products is still limited. More centrally, it is generally accepted that each hydrocolloid affects in a different way the pasting properties of starch (Bahnassey & Breene, 1994; Christianson, Hodge, Osborne,

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& Detroy, 1981; Rojas, Rosell, & Benedito de Barber, 1999). This can be attributed to many factors mainly the molecular structure of hydrocolloids (Abdulmola, Hember, Richardson, & Morris, 1996; Ross-Murphy, 1995; Sudhakar, Singhal, & Kulkarni, 1996) and/or ionic charges of both starches and hydrocolloids (Chaisawang & Suphantharika, 2005; Shi & BeMiller, 2002).

The information on the influences of ionic charges of starches and gums on pasting and rheological characteristics of the starch–gum mixtures are very scarce in the literature. In our preceding article (Chaisawang & Suphantharika, 2005), we investigated the effects of the opposite charges between cationic tapioca starch and negatively charged xanthan gum on pasting and rheological behaviours of the mixture. On the contrary, Shi and BeMiller (2002) studied the pasting characteristics of starch–gum system having the same ionic charges, i.e. potato starch (containing negatively charged phosphate groups) and negatively charged gums (carboxymethylcellulose, carageenans, alginate, xanthan). However, the latter authors did not evaluate the rheological properties of the pastes obtained from these mixtures.

The aim of this study was to investigate effects of guar gum (non-ionic gum) and xanthan gum (negatively charged gum) on the pasting and rheological properties of native tapioca starch (non-ionic starch) and anionic tapioca starch (negatively charged starch). The concentration of gum (0.35%) selected in the present work was based on the levels that commonly employed in food product formulations so as to get practical technological applications. The gelatization behaviours of starches (as controls) and starch–gum mixtures were investigated by using a Rapid Visco-Analyzer (RVA), a differential scanning calorimeter (DSC), and a scanning electron microscope (SEM). In addition, swelling power of the starch granules was also measured. The rheological properties of gelatinized mixtures were measured by using dynamic oscillatory shear technique.

2. Materials and methods

2.1. Materials

Commercial native tapioca starch was kindly supplied by Cho Heng Rice Vermicelli Factory Co. Ltd, Nakhon Pathom, Thailand. Native tapioca starch was phosphorylated by reaction with sodium tripolyphosphate to an anionic tapioca starch as described in Section 2.2. The phosphorus contents of native and anionic tapioca starches were 2 and 73 mg/100 g starch (dry basis), respectively. Xanthan gum and guar gum were obtained from Union Chemical 1986 Co. Ltd, Bangkok, Thailand. Moisture contents of xanthan gum and guar gum were 10.1 and 13.7% w/w, respectively.

2.2. Preparation of anionic tapioca starch

Native tapioca starch was phosphorylated by the procedure of Lim and Seib (1993). Accurately weighted amounts of sodium tripolyphosphate (4.5 g) were dissolved in 241 ml of distilled water. The starch (301.5 g, dry basis) was mixed into the solution by stirring continuously. The slurry was stirred for 1 h at room temperature and dried in an oven at 40 °C to retain 10–15% moisture content. To effect phosphorylation, the dried starch cake was heated for 2 h at 130 °C in a hot air oven. After cooling to room temperature, the starch cake was washed many times by suspending the starch in distilled water and recovering the starch by centrifugation at 2300 rpm for 4 min. Finally, the starch was dried at 40 °C in the hot air oven. The phosphate content was determined by a Flame Emission Photometry (FEP) using the modified AOAC (1990) official methods. Starch was burned in a furnace overnight (16 h) at 525 °C, and cooled down in a desiccator. Ash was dissolved in 1 ml HNO_3. After cooling, ash was transferred to a 250 ml volumetric flask and diluted to give volume. Phosphorus was determined by using a UV–visible detector at 400 nm.

2.3. Pasting properties

Pasting properties of starches or starch–gum mixtures suspended in distilled water were determined by a Rapid Visco-Analyzer (Model RVA-4C, Newport Scientific Pty. Ltd, Warriewood, Australia). Native or anionic tapioca starch (6% w/w, dry basis) was dispersed in 25 ml distilled water (as control) or 0.35% w/w (dry basis) gum solutions. In the case of starch–gum mixtures, gums were first dispersed in distilled water under magnetic stirring, heated to 80 °C for 5 min and cooled to room temperature, and subsequently mixed with dry starch. The starch–gum suspensions were poured into aluminum containers and stirred manually using a plastic paddle for 20–30 s before insertion into the RVA machine. The heating and cooling cycles were programmed in the following manner. The slurry was held at 50 °C for 1 min, heated to 95 °C within 3 min and then held at 95 °C for 2 min. It was subsequently cooled to 50 °C within 3 min and then held at 50 °C for 2 min, while maintaining a rotation speed of 160 rpm. The viscosity is expressed as rapid viscosity units (RVU). The peak viscosity, i.e. the maximum viscosity during pasting, breakdown viscosity, i.e. the difference between the peak viscosity and the minimum viscosity during pasting, setback viscosity, i.e. the difference between the maximum viscosity during cooling and the minimum viscosity during pasting, final viscosity, i.e. the viscosity at the end of the RVA run, pasting temperature (in °C), i.e. the temperature indicating an initial increase in viscosity and peak time (in min), i.e. time to reach the peak viscosity of the starch and starch–gum suspensions were determined.