Effect of Different Hydrocolloids on Pasting Behavior of Native Water Chestnut (*Trapa bispinosa*) Starch

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Summary

The pasting behavior of native Water Chestnut Starch – hydrocolloids mixtures was studied. The effect of Xanthan, Guar, Carboxy Methyl Cellulose and Acacia on Water Chestnut Starch was examined by using micro Viscoamylograph. It was noticed that all hydrocolloids greatly modify the pasting properties of water chestnut starch. Results showed that gelatinization temperature of water chestnut starch was increased by the addition of gum acacia at 0.3 % concentration, whereas guar gum decreased at the same concentration as compared to native water chestnut starch. Xanthan gum and guar gum significantly increased peak viscosity at 0.1 – 0.3 %, but gum acacia at only 0.3 % addition. The breakdown was greatly enhanced by the addition of xanthan gum at 0.1-0.3 % concentrations, but the retrogradation was mostly influenced due to the presence of guar gum at 0.3 %. These results showed that hydrocolloids modify the properties of native water chestnut starch, which can provide a great potential for use in different food products.

Key words

water chestnut, gelatinization properties, amylography, hydrocolloids

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Introduction

Water chestnut (*Trapa bispinosa*) is an edible aquatic angiosperm locally known as "Singhara". It is a floating (rooted) plant, found normally on the water surface of lakes, tanks and ponds. It is one of the important annual aquatic warm season crops. It contrasts well with others foods and is good source of carbohydrates. The high carbohydrate content of water chestnut makes it a very good source of starch for both domestic and industrial uses, as a main raw material or as a food additive, as an additive starch gives the stabilizing and thickening effects and texture modification in food (Suphantharika et al., 2008).

Murty and coworkers (1962) studied some physicochemical properties of Water chestnut starch. The swelling and solubilization of Water chestnut starch was noticed between 60 ºC – 75 ºC. The gelatinization of Water chestnut starch was little higher than that of potato starch (Shoemaker, 1986). They also investigated the effect of varying concentrations of sugar on the gelatinization behavior of Water chestnut starch and lotus root starch. The same trend was observed in starches from both sources.

Non- starch hydrocolloids (named "hydrocolloids"), on the other hand, particularly native and modified polysaccharides, show many functional properties to manage the textural and rheological characteristics of foods, to make better the moisture retentions, and to uphold the overall product qualities during storage (Glicksman, 1969, 1982a, b). Many studies have been reported using an aqueous system of starch and hydrocolloids as an experimental model to simplify the role and possible worth of hydrocolloids for starch – based food products. These comprise that the addition of hydrocolloids improve or modifies the retrogradation and gelatinization behaviors of starch (Williams et al., 2000; Alloncle et al., 1989; Christianson et al., 1981; Fanta et al., 1996; Alloncle et al., 1991; Gudmundsson et al., 1991; Kim et al., 1977; Sajjan et al., 1987; Tye, 1988; Yoshimura et al., 1998, 1999; Kohyama et al., 1992; Yousria et al., 1994) and bread staling (Armero et al., 1998; Davidou et al., 1996) or the freeze thaw stability of starch – based systems (Lee et al., 2002).

The majority of the information is obtained about starch – hydrocolloids systems, but there are still unidentified characteristics because of the intricacy of such systems. Furthermore, according to the information reported in the literature, there are many conflicting properties, while the association of these properties to real food products is still bounded. More centrally, it is generally believed that each hydrocolloid affects in a different way the pasting properties of starch (Rojas et al., 1999; Bahnassey et al., 1994; Christianson et al., 1981). This can be attributed to many factors mainly the molecular structure of hydrocolloids (Sudhakar et al., 1996; Abdulmola et al., 1996; Ross-Murphy, 1995) and/ or ionic charges of both starches and hydrocolloids (Chaisawang et al., 2005; Shi et al., 2002).

The aim of this study was to examine the effects of guar gum, xanthan gum, carboxy methyl cellulose, and acacia gum on the pasting properties of native water chestnut starch. The concentration of gum (0.1% - 0.3 %) chosen in the present work was based on the levels that normally are used in food product formulations so as to get practical technological applications. The retrogradation properties and gelatinization behavior of starches (as controls) and starch-gum mixtures were investigated by Brabender Viscoamylograph.

Materials and methods

Water chestnut starch (WCS) was isolated from dried water chestnuts; food grade xanthan gum (XG), guar gum (GG), carboxy methyl cellulose (CMC), and acacia (AC) were purchased from the local market of Karachi, Pakistan.

Amylography

The gelatinization and retrogradation behavior of water chestnut starch was studied using Micro Viscoamylograph (Brabender Germany). Water chestnut starch (5 %) was mixed with 0 - 0.3 % of selected hydrocolloid in distilled water. The mixture was then heated in a Brabender Viscograph (Model D- 47055) from 35 °C to 95 °C at a rate of 1.5 °C/min at 75 rpm, held for 10 min at 95 °C and then cooled back to 40 °C. It was finally kept at 40 ºC for 10 min. The resulting behavior was studied for the following parameters: gelatinization temperature, peak viscosity, breakdown during heating (the difference between the peak viscosity and the viscosity at the beginning of first holding period), and set back or retrogradation during cooling (the difference between the viscosity at 40 ºC and the viscosity after the first holding period). All measurements were carried out in triplicate.

Statistical analysis

The pasting data reported are means of triplicate determinations. The statistical analysis of the results was conducted by the analysis of variance (ANOVA) and LSD test using SPSS version 11.0 for Windows program. Significant differences were reported for $P \leq 0.05$.

Results and discussion

Gelatinization temperature

Gelatinization temperatures of water chestnut starch-gum systems at 0.1 % concentration of gums are shown in Table 1. It was observed that, Water chestnut starch gelatinization temperature was greatly reduced when CMC and XG were added. Taking into account that gums did not produce changes in gelatinization temperature, this decrease in pasting temperature can be due to the interactions between starch (mainly leached amylose) and gums as pointed out by Shi and BeMiller (2002). Acacia slightly increased the gelatinization temperature of water chestnut starch. No significant effect was observed on addition of GG. Increasing the concentration of gums up to 0.2 % decreased the gelatinization temperature as compared to control, whereas, by the addition of 0.3 % concentration of gums, only gum AC delayed the gelatinization temperature with respect to the control one (Table 2).

Table 1. Effect of addition of XG, GG, CMC, and AC on the peak viscosity (PV), gelatinization temperature (Tg), Breakdown (BD), Setback (SB) of 5 % Water chestnut starch (WCS)

Ingredients	PV (BU)	Tg (°C)	BD (BU)	SB (BU)
5% WCS	72 ±2^a	77.2 ±0.1^a	0 ±0.0^a	25 ±0.1^a
5% WCS + 0.1% XG	98 ±1^b	71.1 ±0.2^b	19 ±0.2^b	36 ±0.3^b
5% WCS + 0.1% GG	79 ±0.5^c	77.5 ±0.1^a	2 ±0.1^c	34 ±0.2^c
5% WCS + 0.1% CMC	66 ±1^d	74.2 ±0.3^c	1 ±0.0^d	32 ±1.0^d
5%WCS + 0.1% AC	65 ±2^d	79.2 ±0.1^d	2 ±0.2^c	34 ±0.1^c

Assays were performed in triplicates. Mean values followed by different superscripts within the same columns are significantly different ($P \leq 0.05$).

Table 2. Effect of addition of XG, GG, CMC, and AC on the peak viscosity (PV), gelatinization temperature (Tg), Breakdown (BD), Setback (SB) of 5% Water chestnut starch (WCS)

Ingredients	PV (BU)	Tg (°C)	BD (BU)	SB (BU)
5% WCS	72 ±2^a	77.2 ±0.1^a	0 ±0.0^a	25 ±0.1^a
5% WCS + 0.2% XG	159 ±0.1^b	69.4 ±0.1^b	52 ±0.1^b	41 ±0.3^b
5% WCS + 0.2% GG	135 ±0.2^c	70.9 ±0.3^c	0 ±0.0^a	44 ±0.8^c
5% WCS + 0.2% CMC	73 ±0.5^a	75.2 ±0.2^d	1 ±0.0^c	46 ±0.5^d
5%WCS + 0.2% AC	67 ±0.3^d	76.8 ±0.1^e	0 ±0.0^a	16 ±0.1^e

Assays were performed in triplicates. Mean values followed by different superscripts within the same columns are significantly different ($P \leq 0.05$).

Table 3. Effect of addition of XG, GG, CMC, and AC on the peak viscosity (PV), gelatinization temperature (Tg), Breakdown (BD), Setback (SB) of 5 % Water chestnut starch (WCS)

Ingredients	PV (BU)	Tg (°C)	BD (BU)	SB (BU)
5% WCS	72 ±2^a	77.2 ±0.1^a	0 ±0.0^a	25 ±0.1^a
5% WCS + 0.3% XG	170 ±0.9^b	70.6 ±0.1^b	52 ±0.2^b	37 ±0.3^b
5% WCS + 0.3% GG	158 ±0.2^c	67.2 ±0.2^c	7 ±0.1^c	87 ±0.2^c
5% WCS + 0.3% CMC	108 ±0.1^d	72.4 ±0.1^d	0 ±0.0^a	48 ±0.1^d
5%WCS + 0.3% AC	49 ±0.3^e	81.6 ±0.6^e	1 ±0.0^d	17 ±0.2^e

Assays were performed in triplicates. Mean values followed by different superscripts within the same columns are significantly different ($P \leq 0.05$).

Spies, et al, (1982) linked the difference in the gelatinization temperature to the availability of water for amylopectin melting. The sugar or any other solute added to water decreased the availability of water in the system which therefore requires the higher energy to interact with other components in the system. Generally, decrease in the gelatinization temperature was influenced by the greater water availability (White, et al., 1989). Low gelatinization temperature offer greater availability of starch to amylolytic enzymes during baking process (Rojas et al., 1999), which is enviable in bread making.

Peak viscosity

The peak viscosity of WCS was affected by the addition of all hydrocolloids. Initially, as shown in Table 1, an increase in peak viscosity of WCS at 5 % concentration was observed in the presence of 0.1 % concentration of XG and GG, where it was decreased by CMC and AC from 66 BU to 65 BU respectively. XG and GG approximately were doubling the peak viscosity when the concentration of gums was increased up to 0.2 % (Table 2), whereas CMC and gum AC had no significant effect. The behavior in peak viscosity was similar in case of XG and GG (0.3 %) but the change was observed with CMC (Table 3), which increased the peak viscosity up to 108 BU, whereas gum AC significantly decreased this effect. According to Ikeda, et al. (2002) the increase in viscosity is due to the swelling of starch granules accompanied by leaching of amylose whereas granules may rupture during further heating. The equilibrium point between the swelling and rupture of starch granules is defined as peak viscosity. The same results were explained by Pongsawatmanit et al. (2007); the increase in viscosity was due to the interaction of solute with polysaccharide that made starch granules restricted and tightened what resulted in a slow leaching of amylose chain. Due to the tightened structure, the swelling of granule would enhance further.

Breakdown

The effect of different gums on the breakdown of WCS was observed. The marked increase was noticed by the addition of XG at all concentrations (0.1 – 0.3 %) as compared to the starch alone, whereas the GG, CMC, and AC have showed negligible effects (Table 1-3). This showed that native WCS was more stable to heat and mechanical shear as compared to the starch – gums systems.

Setback or retrogradation

According to Christianson, et al. (1981) the mixture of swollen granules, granule fragments, and molecularly dispersed starch molecules tends to associate or retrograde as the paste cools. This results in increased viscosity. The addition of gums enhanced the retrogradation of WCS (Tables 1-3). The significant increase was observed by the addition GG at the concentration of 0.1 % - 0.3 % but noticeably, gum AC decreased this effect at 0.2 % and 0.3 % concentrations.

Conclusion

This work clarified that the pasting characteristics of the nWCS were largely affected by GG, XG, CMC and ACA addition and depended on their concentration. Amylograh results showed that gelatinization temperature, peak, breakdown, and setback viscosities of the nWCS dispersions during pasting increased with increasing gum concentrations. The effect of different hydrocolloids on the pasting behavior may play a significant role in food formulations. The textural characteristics and consistency of ready to eat foods may be improved by addition of different combinations of gums and Water chestnut starch. Textures of baked products may also be improved by these combinations.

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