

Effect of pH and Sucrose on Morphology, Swelling and Pasting Properties of Rice Starch Suspension

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Abstract

The effect of pH (5, 7 and 9) and sucrose concentration (0, 10 and 20%w/w) on morphology, swelling and pasting properties of rice starch (RS) suspension were investigated. Sucrose concentration had more effect on morphology of rice starch granules during heating to 75 °C for 30 min than pH. When pH was increased, the granule sizes were slightly larger. On the contrary, when sucrose concentration was increased, the granule sizes were smaller. Addition of sucrose reduced the rupture of starch granule during heating. The effect of pH and sucrose concentration on swelling factor had the same result as on morphology. At pH 9 without sucrose addition starch suspension had the largest swelling factor, while the starch suspension with pH 5 and 20%w/w sucrose had the smallest swelling factor. For pasting properties determined by rapid visco analyzer (RVA), we found that when pH was increased, the peak and final viscosity were slightly increased. However, when sucrose concentration was increased, the peak and final viscosity were increased. At pH 9 and 20%w/w sucrose concentration starch suspension had the highest peak and final viscosity. In conclusion swelling and pasting properties can be adjusted by pH and sucrose addition.

Keyword: Rice starch, pH, Sucrose, Morphology, Swelling Factor, Pasting properties

1. Introduction

Starch is a major storage energy reserve in plants where it exists as insoluble granules. Starch granules are extracted commercially from many botanical sources including potato, maize, wheat and rice to produce a wide variety of industrial products (Tester & Karkalas, 2002). Starch is often used in certain food products, it is used to improve thickening and gelling properties. When dry native starch granules are suspended in a sufficient amount of water and then heated, they absorbed water and swell to several times their original sizes (Hagenimana *et al.*, 2005). Gelatinization, pasting, and subsequent gel properties of starch are key functional properties that determine many applications of starch in the food industry. Usually these properties are not optimal in native starch, and thus need to be modified by various techniques to suit the relevant end product (Gunaratne *et al.*, 2007).

Sugars are commonly used in starch based foods in order to optimize the process operation and cause some textural modification in addition to its role as a sweetening agent. Influence of sugars on rheological properties of starch has also been discussed by several researchers. With increase of sugar concentration, peak viscosity and pasting temperature of wheat starch increase substantially (Bean & Yamazaki, 1978; D'Appolonia, 1972; Richardson *et al.*, 2003; Gunaratne *et al.*, 2007).

In food preparation, starch-based products can be submitted to different processing and storage conditions, which sometimes change the physical and/or chemical properties of these products, because they are strongly dependent on heat, pH, and shear conditions. The role of pH can be critical, however, research on this topic is scarce. Mali *et al.* (2003) investigated the

effect of pH (3, 5, and 6) on gelatinization of yam and tapioca starches. They reported that pasting properties of both starches were affected by pH.

The objective of this study was to investigate the effect of pH and sucrose concentration on morphology, swelling and pasting properties of rice starch (RS) suspension.

2. Material and method

2.1. Materials

Rice starch was kindly supplied by Cho Heng Co. Ltd., Thailand. Sucrose was purchased from Mitr Phol Sugar Corp., Ltd., Thailand. Hydrochloric acid and sodium hydroxide were purchased from Merck (Darmstadt, Germany). Moisture content of rice starch was 11.85 % w/w.

2.2. Method

2.2.1. Morphology and granule size

Morphology and granule size of rice starch were studied by light microscopy. Rice starch suspensions (8%w/w) with different sucrose concentration (0, 10 and 20%w/w) were prepared. The pH of suspensions was adjusted to 5, 7, and 9 using 0.5 N HCl or 0.5 N NaOH. The starch suspensions were then heated in a water bath at 75 °C for 30 min. The morphology and size of rice granules were observed promptly using a light microscope (Leica) with 100× magnification.

2.2.2. Swelling factor

Swelling factors of rice starch suspensions (8%w/w) with different pH and sucrose concentration heated to 75 °C for 30 min were determined by blue dextran dye exclusion method (Tester and Morrison, 1990). All measurements were done with 2 replicates.

2.2.3. Pasting properties

Pasting properties of rice starch suspensions (8%w/w) with different pH and sucrose concentration were determined with AACC Approved Method using a Rapid Visco Analyzer (RVA, Newport Scientific, Warriwood, Australia). All measurements were done with 2 replicates.

3. Result and discussion

3.1.1. Morphology and granule size

The light microscopic images of rice starch granules heated at 75 °C for 30 min are shown in Fig. 1. The granules of rice starch had an irregular shape. The starch suspension without sucrose addition, starch granules were largest size at pH 9. Addition of sucrose at all pH reduced the rupture of starch granule during heating.

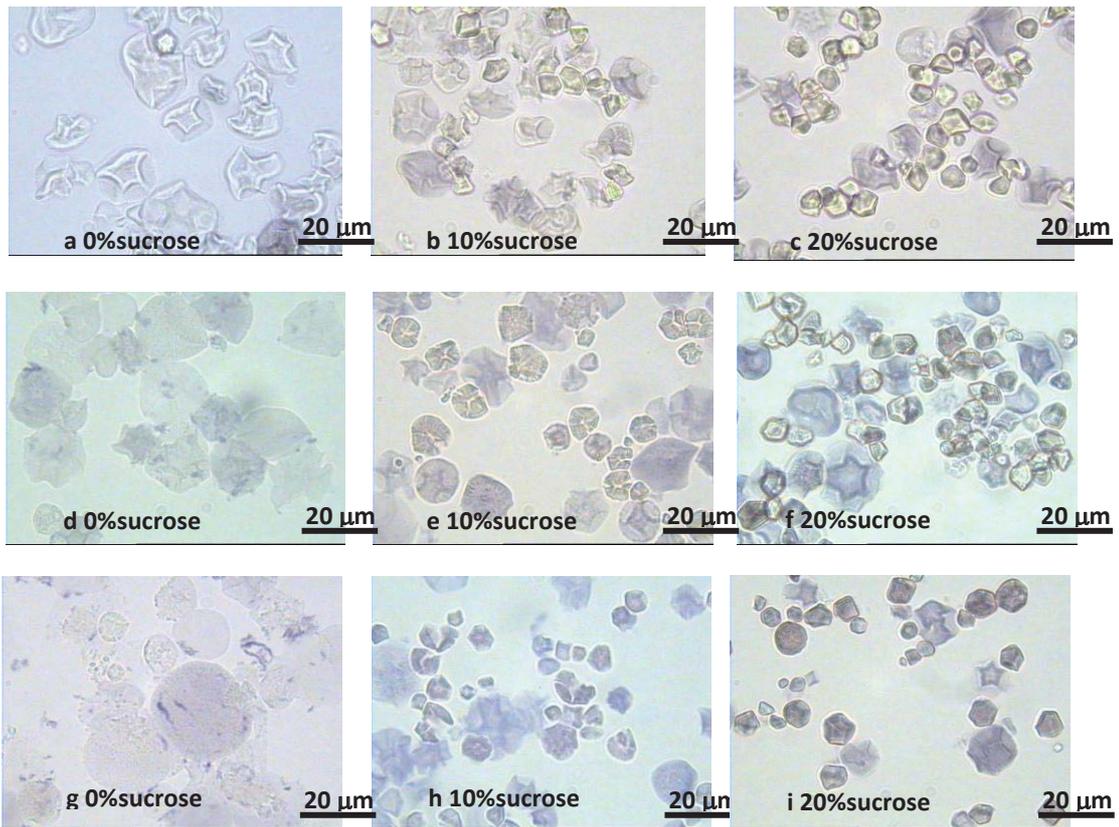


Figure 1. Light microscopic images of rice starch granules heated at 75 °C for 30 min. (a–c) sugar concentration were 0, 10 and 20%w/w at pH 5; (d–f) at pH 7; and (g–i) at pH 9. (100× magnification)

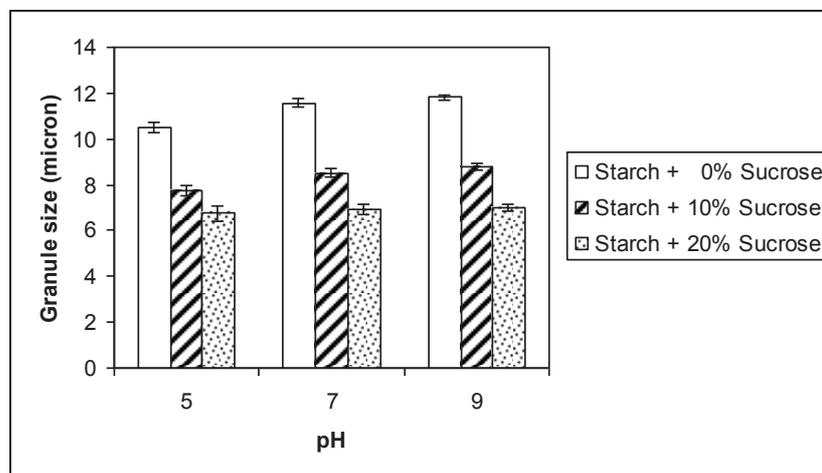


Figure2. Granules size of rice starch heated at 75 °C for 30 min at different pH (5, 7 and 9) and sucrose concentration (0, 10 and 20%w/w).

Sucrose concentration had more effect on morphology of rice starch granules during heating to 75 °C for 30 min than pH. When pH was increased, the granule sizes were slightly larger. On the contrary, when sucrose concentration was increased, the granule sizes were smaller. Starch suspensions with sucrose addition showed smaller granule diameter as compared with those in starch suspensions without sucrose. The result showed that at pH 5

with 20% sucrose concentration, starch granules had the smallest size (6.98 μm .), while at pH 9 without sucrose addition, had the largest size (11.82 μm .) (Fig. 2).

3.1.2. Swelling factor

We found that addition of sucrose was able to reduce swelling factor of rice starch at all pH (Table 1). At pH 9 without sucrose addition, starch suspension had the largest swelling factor, while the starch suspension at pH 5 with 20%w/w sucrose concentration had the smallest swelling factor. Sucrose decreased water-binding capacity of starch granules and hence, swelling of starch granule was decreased. At low water contents, starch granule had the lower swelling factor than high water content.

Table 1. Swelling factor of rice starch (RS) suspensions (8%w/w) was heated to 75 °C for 30 min at different pH and sucrose concentration.

Sample	pH 5	pH 7	pH 9
RS + 0% Sucrose	5.11 \pm 0.21	7.71 \pm 0.03	7.90 \pm 0.28
RS + 10% Sucrose	4.30 \pm 0.30	6.25 \pm 0.43	6.59 \pm 0.09
RS + 20% Sucrose	2.00 \pm 0.06	4.03 \pm 0.38	4.99 \pm 0.09

There was a good linear relationship between swelling factor and pH value with $R^2 = 0.801$, 0.857 and 0.960 for 0, 10 and 20% sucrose added to starch suspension respectively (Fig. 3).

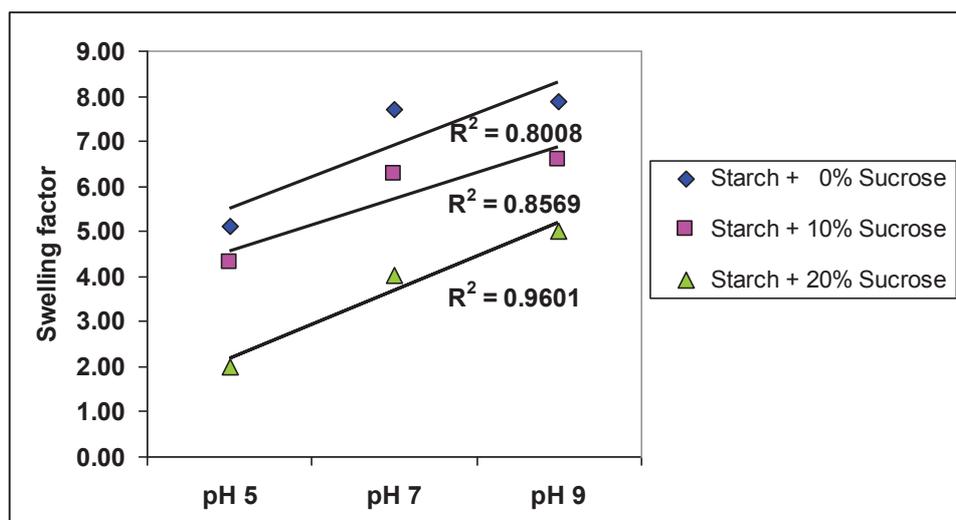


Figure 3. Swelling factor of rice starch suspension (8%w/w) heated at 75 °C for 30 min at different pH (5, 7 and 9) and sucrose concentration (0, 10 and 20%w/w).

3.1.3. Pasting properties

The peak viscosity was considered to represent the equilibrium point between swelling and rupture of starch granules. Swelling of granules, accompanied by leaching of amylose, increases the viscosity, while granules may rupture during further heating, which results in a decrease in the viscosity. During the holding period, the sample remains subjected mechanical shear stress, which can lead to further disruption of starch granules and amylose leaching. As the sample is subsequently cooled down, the viscosity increases to a final viscosity (Pongsawatmanit *et al.*, 2002).

The result showed that when pH was increased, the peak and final viscosity were slightly increased. However, when sucrose concentration was increased, the peak and final viscosity were obviously increased (Fig. 4). At pH 9 and 20%w/w sucrose concentration starch suspension had the highest peak and final viscosity (Table 2). The increasing of peak and final viscosity may occur from pH. When pH was increased, starch granules swelled more to many times their original size leading to viscosity of system was increased. Moreover, the increasing of peak and final viscosity may occur because sucrose addition. A similar result was found by Pongsawatmanit *et al.* (2002), they reported that the peak and final viscosity of tapioca starch increased with increasing sucrose content. Effect of sugars on pasting properties of starch has also been discussed by other researcher. With increase of sugar concentration, peak viscosity of wheat starch increase substantially (Bean & Yamazaki, 1978; D'Appolonia, 1972; Richardson *et al.*, 2003). Both the peak and final viscosity of rice starch suspension were increased with increasing pH and sucrose concentration.

Table 2. Pasting properties of rice starch (RS) suspensions (8%w/w) containing 0, 10 and 20% w/w sucrose concentration at different pH (5, 7 and 9).

Sample	Peak viscosity (RVU)	Final viscosity (RVU)
pH 5		
RS + 0% Sucrose	126.08 ± 2.47	141.38 ± 2.77
RS +10% Sucrose	188.46 ± 6.31	182.29 ± 4.07
RS +20% Sucrose	246.13 ± 2.77	243.79 ± 2.89
pH 7		
RS + 0% Sucrose	115.88 ± 2.53	172.25 ± 5.77
RS +10% Sucrose	182.58 ± 1.77	212.50 ± 2.36
RS +20% Sucrose	259.00 ± 1.65	267.08 ± 3.89
pH 9		
RS + 0% Sucrose	112.42 ± 10.14	161.29 ± 11.61
RS +10% Sucrose	176.25 ± 0.35	212.75 ± 8.60
RS +20% Sucrose	252.88 ± 0.29	272.17 ± 0.94

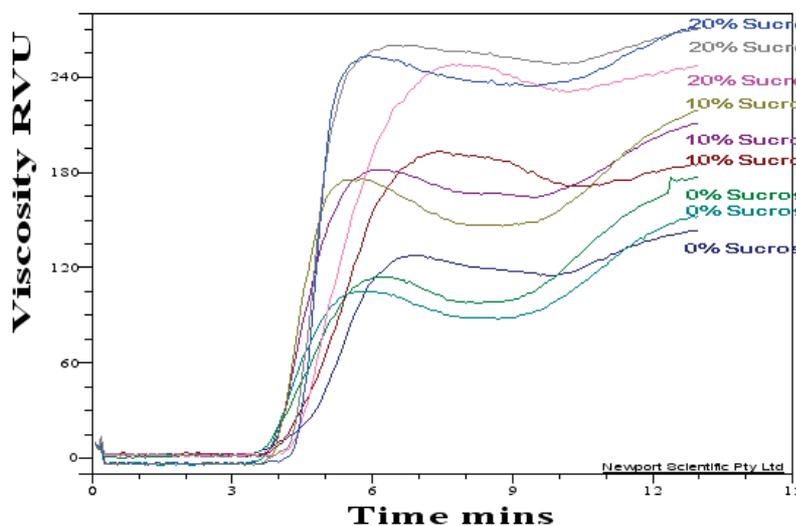


Figure 4. RVA viscosity profiles of rice starch suspensions containing 0, 10 and 20% w/w sucrose concentration at different pH (5, 7 and 9).

4. Conclusion

This study found that swelling and pasting properties can be adjusted by pH and sucrose addition. When pH was increased, swelling factor, peak and final viscosity were increased. Moreover, addition of sucrose reduced the rupture of starch granule during heating and when sucrose concentration was increased, the granule sizes were smaller.

5. References

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