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Research Article

Effects of Sugars on the Light Transmittance of Tapioca Starch Pastes during Cold Storage

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Abstract: The aim of this study is to study the influence of sugars (glucose, sucrose and trehalose) on the light transmittance of Tapioca Starch (TS) gels during cold storage. The effects of sugars on the light transmittance of TS gels were investigated at the concentration of starch 2% (w:w) during cold storage. The results showed the light transmittance of TS gels could be improved by sugar addition, according to the sugar type and concentration. The light transmittance increased with the increase of the concentration of the same kind of sugar. And the improvement of light transmittance with the sugar type was according to the order: trehalose>sucrose>glucose. Whether addition of sugar or not, light transmittance decreased with the extension of storage days. Therefore, light transmittance experiment is a simple and inexpensive method to study the effects of sugars on the retrogradation of starch gels with low-concentration.

Keywords: Cold storage, light transmittance, sugar, tapioca starch

INTRODUCTION

A variety of methods have been used to evaluate retro-gradation in low-concentration pastes of starches from various sources (Karim *et al*., 2000). A physical characteristic of aging gelatinized starch solutions is the increase in turbidity which results from changes in density distribution due to phase separation (Miles *et al*., 1985; Jacobson *et al*., 1997). When starch gels are refrigerated, the retro-gradation of starch gels can be accelerated. The retro-gradation leads to phase separation and the light transmittance of low-concentration pastes of starches will be reduced. Obviously, the determination of light transmittance is a simple and low-cost method for evaluating retro-gradation of starch pastes relative to other detection methods such as DSC, TPA and SEM.

As is known to all, Tapioca Starch (TS) is featured by bland flavor, clear paste appearance and high viscosity, so it can be used in food including baby food as a filler material or a thickening and gelling agent (Sanguanpong *et al*., 2003). And the price of TS is low in the world market when compared with other starch. So far the use of TS in food processing has become more and more popular. On the other hand, glucose, sucrose and trehalose are universal sweeteners used in food industry. In addition, these sugars originate from nature and are safer than chemical additives. Meanwhile, adding these sugars in foods may ensure the foods of high quality in supply chains. Our previous studies had confirmed that sugar addition in tapioca starch gels could effectively delay retro-gradation of TS gels by means of DSC, SEM and freeze-thaw stability tests (Zhang *et al*., 2012). However, few studies have been reported on the influence of these sugars on the light transmittance of starch pastes with low-concentration, not to mention TS gels. Thus, the objective of the article was to study in detail the effects of glucose, sucrose and trehalose on the light transmittance of TS gels with low-concentration.

MATERIALS AND METHODS

Materials: Tapioca starch was supplied by Guangxi State Farms Mingyang Bionchemical Group, Inc., China. The moisture content and amylose content of tapioca starch was 134.1 and 171.0 g/kg, respectively (AACC, 2000). Trehalose, sucrose and glucose were analytical reagent purchased from Sinopharm Group Co., Ltd., China.

Sample preparation: Tapioca starch suspensions (2%, w:w) containing different levels (0, 1, 2 and 4%, respectively w:w, based on the mass of starch suspensions) of sugars (sucrose, glucose and trehalose) were added into 250 mL beakers. The beakers were

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placed in 95°C water bath for 25 min to ensure complete gelatinization. Afterwards some water was added to supplement the loss of water evaporation. The beakers were then placed briefly under slight vacuum to remove air bubbles. The pastes were transferred to volumetric flask and cooled in 25°C water bath for 1 h.

Determination of light transmittance: Initial light transmittance was determined by absorbance at 640 nm (Miles *et al.*, 1985) using a UV 2100/visible spectrophotometer equipped with a programmable cell changer. The remaining cooled pastes were stored in a refrigerator at 4°C. After 1, 3, 5, 7, 10, 14, 21, 28 days, respectively at 4°C, the pastes in flasks were put in 25°C water bath for 1h and were agitated briefly by a wrist-arm shaker before the determination of the light transmittance.

Statistical analysis: The results of the light transmittance tests were reported as mean±S.D. for three replications. The difference between means was determined using the Duncan's new multiple range test. All data were statistical analyzed using SPSS software (version 12.0 for Windows; SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

To discuss the effects of sugars on the light transmittance of 2% tapioca starch pastes, transmission of TS (2%, w:w) gel in the absence or presence of sucrose, glucose or trehalose at 4°C were determined and presented in Fig. 1 to 3.

The transmission of TS (2%, w:w) gels decreased along with cold preservation time. From 0 to 7 days, the downward trend was obvious. And after that the transmission didn't drop obviously and the trend sloped gently. The changes indicated the retro-gradation of starch gels was fast in the early stage of refrigeration and then reached saturation.

The pastes containing different amounts of sugars (sucrose, glucose or trehalose) had the same changing tendency as the pastes with no sugar. But comparing with the pure starch pastes, the samples in presence of sugars sloped gently and the downward trend became less obvious with the prolongation of the storage time. That is to say, the addition of sugars could improve the transmission obviously and it increased with the addition amounts of sugars. For example, as for the pastes containing different amounts of trehalose (starch: trehalose = 2:1, 1:1, 1:2, w:w), the transmission was 15.7, 18.4 and 20.1 respectively, while the pure paste is 10.4 after 28 days. Because transmission is positively related to the retro-gradation of TS gels, the downtrends in Fig. 1 to 3 showed that sugars could effectively retard the retro-gradation of low concentration starch pastes. In case of different kinds of sugars, the improvement of transmission was in the order: trehalose>sucrose>glucose (Fig. 1 to 3). These facts showed that of these sugars, trehalose performed best in curbing the retro-gradation of TS gels, which were consistent with our previous results (Zhang *et al.*, 2012).

The possible reason for the improvement of the retro-gradation by sugars was that starch pastes containing sugars formed strong interaction between sugars and starch molecular via intermolecular hydrogen-bonding, which prevented starch chain

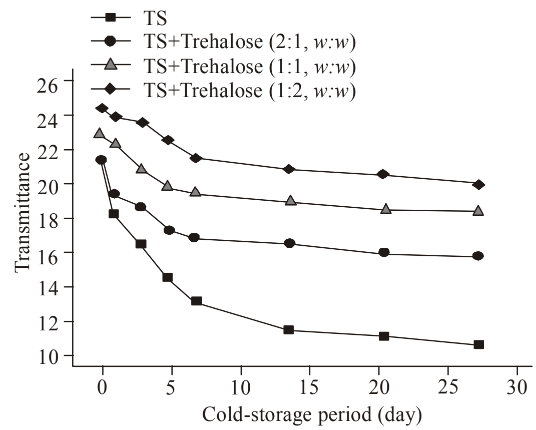

Fig. 1: Transmission of TS (2%, w:w) gel in the absence or presence of trehalose at 4°C

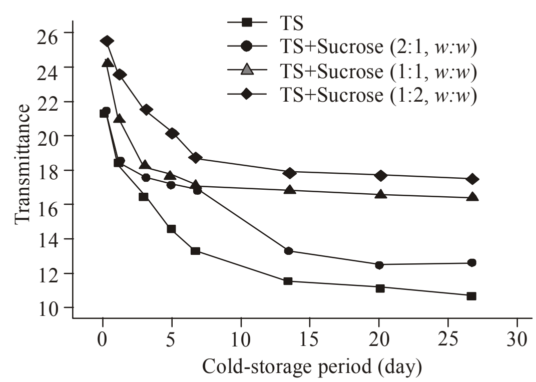

Fig. 2: Transmission of TS (2%, w:w) gel in the absence or presence of sucrose at 4°C

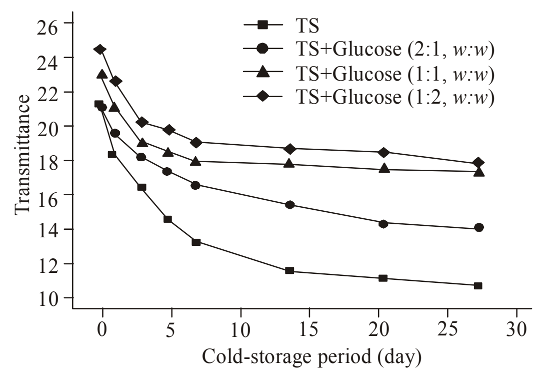

Fig. 3: Transmission of TS (2%, w:w) gel in the absence or presence of glucose at 4°C

re-associating and then reduced the size of starch chain. More specifically, sugar molecules interact with starch molecular chains to stabilize the amorphous and entangled matrix of gelatinized starch (Spies and Hoseney, 1982; Slade and Levine, 1987). The direct result of the presence of relatively small size of starch chain was that light was allowed to pass through the starch gels instead of being refracted and/or scattered.

CONCLUSION

This study shows that sugar addition could improve the light transmission of TS (2%, w:w) gels. With the increase of sugar addition and cold storage time, the improvements appeared more obvious. In case of different kinds of sugars, the improvement of transmission was in the order: trehalose>sucrose >glucose. The results further proved that sugars could retard the starch retro-gradation and trehalose was a good candidate for curbing the retro-gradation of TS gels. And light transmittance provides a simple and inexpensive method for studying the effects of sugars on the retro-gradation of starch gels with low-concentration.

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