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Rheological and Textural Characteristic of Restructured Fruit Puree

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ABSTRACT

Sago starch is a cheap form of starch which is isolated from sago palm (Metroxylon spp.) and is available in abundance in South East Asian countries. Given its low cost, Sago starch has great potential to be used as a substitute for other forms of starch. The objectives of this work were to study the effects of paste concentration on the rheological behaviour of sago starch paste, their texture properties and their freeze thaw stability compared to other types of starch. The rheological properties of sago starch were investigated at different paste concentrations (3-8 wt %). The textural properties of the samples were investigated by examining the gel strength of the samples. The percent syneresis of sago starch was also studied to examine the freeze-thaw stability of the material. The freeze thaw stability of sago starch with the addition of certain biopolymers were also characterized.

Keywords: Freeze-thaw, rheology, starch concentration, texture analysis

INTRODUCTION

The use of starch has continued to grow over the years. Starch has been used in a wide range of products, either as raw material or as an additive, and thus, starch plays an important role in many industries such as food, pharmaceuticals, textiles and even biodegradable polymers. The choice of starch for the production of food ingredients would depend on factors such as availability, cost, efficiency of processing and quality of the final product. Sago starch is a cheap source of starch that is available in abundance in South East Asian countries. It may be used as a thickener in food and can replace more expensive sources of starch. There is lack of literature on sago starch especially on its rheological characterization. Any improvement in this area will lead to better utilization of sago starch and eventual cost savings. This study will also increase the economic value of sago and provide more choices for food manufacturers when selecting their food ingredients.

Sago starch is a form of starch isolated from sago palm (Metroxylon spp.). Sago starch is extracted from the sago palm trunk. The tall heavy trunks with pinnate leaves accumulate starch, and just before flowering is initiated, the entire trunk is cut, and prepared for the extraction of sago.

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MATERIALS AND METHODS

Sample Preparation

Starch paste was prepared by dispersing a required amount of dry starch in distilled water in a magnetic stirrer plate for 10 minutes at room temperature. The starch dispersions were brought up to 90°C in a water bath and stirred for 15 minutes to achieve complete gelatinization. The beaker was then weighed again and the volume corrected for any evaporation loss on heating using hot distilled water.

Rheological Measurement

The rheological studies were performed on the Bohlin CV0 controlled stress rheometer. The rheological studies were performed using cone and plate geometry with roughened surface to eliminate wall slip. Solvent trap was applied to eliminate moisture loss. All experiments were replicated thrice. Steady shear flow properties were measured by subjecting samples to increasing shear stress and measuring the corresponding shear rate in the range of 0.001 to 1000s-1. For dynamic rheological properties, samples were subjected to a stress sweep (0.01 to 100 Pa) at 0.01 and 10 Hz to determine the linear viscoelastic region. Frequency sweep experiments were carried out within the linear viscoelastic region and the viscoelastic parameters (G', G") were measured.

Textural Measurements

Gel strength of samples was determined by registering resistance to puncture in a Stable Micro Texture Analyzer fitted with 5 kg load cell. A 10 mm diameter delrin plunger penetrated the samples at 0.5 mm/s to a depth of 8 mm. Gel strength was measured as the penetration force required to broke gels. Measurements were made on three different fresh surfaces in recently opened 100 ml jars (55mm❑) of each sample.

Freeze-thaw Analysis

20 g (accurate weight) of the starch paste was added into each pre-weighted 15 mL centrifuged tubes, and allowed to cool to 30°C. Then these starch paste samples were frozen at -18°C in a freezer for 20 hours. After 20 hours, all tubes were removed from the freezer and thawed at room temperature for 4 hours. Thawed samples were centrifuged at 3000 rpm for 15 minutes. The clear liquid was decanted, and the residue weighed. The percentage syneresis was then calculated as

RESULTS AND DISCUSSION

Rheological Characterisation

Fig. 1 shows that sago starch paste exhibits very shear-thinning behaviour with a presence of a Newtonian plateau region at low shear rate values and were well described by a modified Cross model, wherein the infinite shear viscosity in the original Cross model was considered negligible. From non-linear regression analysis (using Sigma plot 7.0), the magnitude of zero shear viscosity increased as the concentration increased (Table 1).

Fig. 2 shows the frequency spectra of sago starch at different concentrations. Sago starch at lower concentration (3%) shows a G'-frequency dependence with G' increasing as frequency increased. In contrast, samples with higher concentration (8%) exhibits a more gel like behaviour with G' almost independent of frequency.

Textural Characterisation

Fig. 3 shows that gel strength of sago starch increased exponentially as the concentration of starch increased. The regression model resulted in a gel strength constant of 11.73 N, an exponential constant of 0.5561 and the coefficient of regression (R^2) was 0.992.

Freeze-thaw Stability

As depicted in *Fig. 4*, sago starch shows poor resistance to freeze thaw cycles, where even after 1 cycle, the % syneresis was almost 50% and increased to more than 55% after 5 cycles. Starch gel becomes spongy after the first cycle. The freeze thaw stability of sago starch can be improved by adding a certain amount of biopolymers.

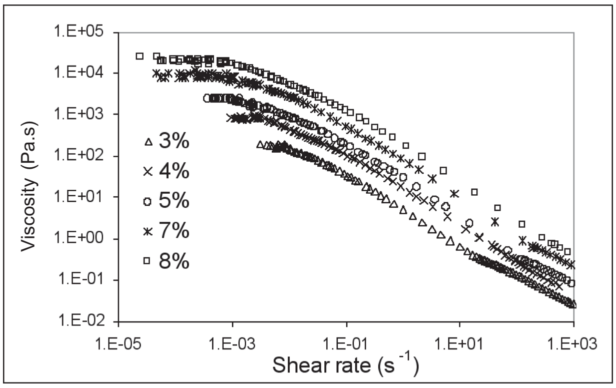

Fig. 1: Shear profile of sago starch at different concentrations (2-8% w/v)

TABLE 1
Regression coefficient based on cross model for sago starch paste at different concentrations

Conc. w/v (%)	η_o (Pa.s)	K	N	R^2
3.00	331.12	56.04	0.863	0.993
4.00	850.14	76.94	0.943	0.984
5.00	2178.56	126.84	0.814	1.000
6.00	4926.33	174.91	0.906	0.988
7.00	9584.70	279.26	0.940	1.000
8.00	22124.86	330.40	0.940	1.000

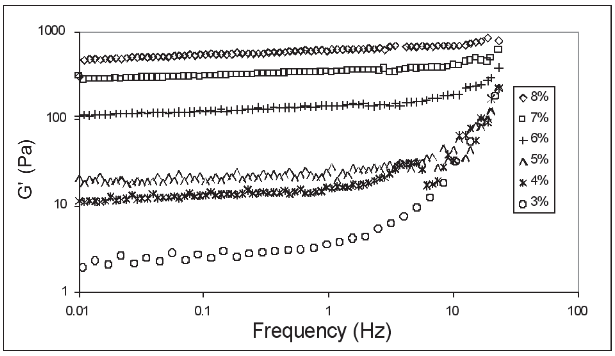

Fig. 2: Comparisons of storage modulus of sago starch at different concentrations

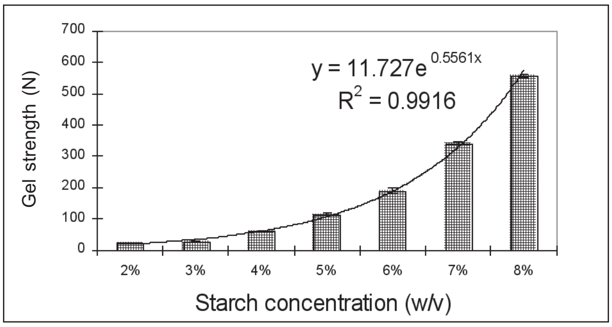

Fig. 3: Gel strength of sago starch at various concentrations

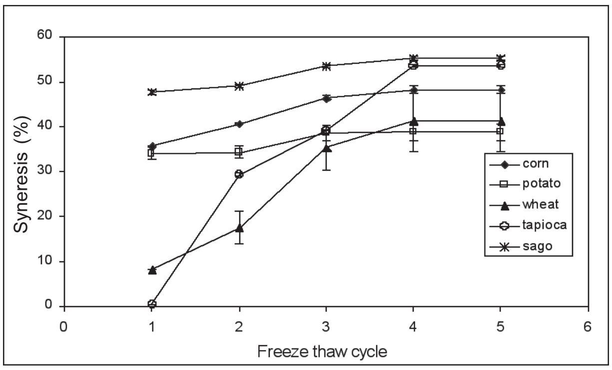

Fig. 4: Syneresis of 4% sago starch compared to other starch with repeated freeze thaw cycle

Fig. 5 shows that the freeze-thaw stability of sago starch increases with the addition of carrageenan, gellan, xanthan and whey protein, but decreases with the addition of alginate and locust bean gum. Mixture of starch and carrageenan gives the best resistance towards freeze-thaw treatments.

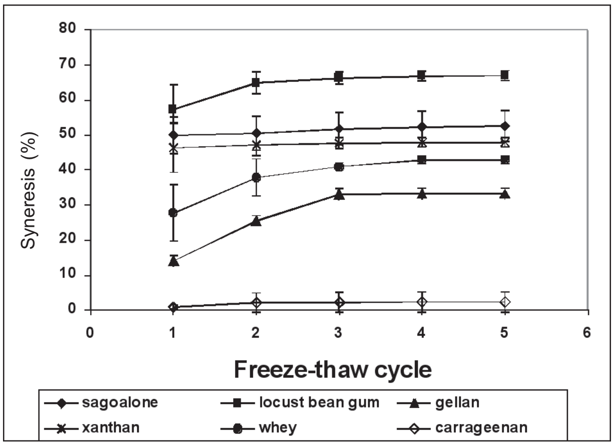

Fig. 5: Syneresis of 4 %(w/v) sago starch with 0.5% biopolymers with repeated freeze thaw cycle

CONCLUSIONS

Sago starch paste exhibits a shear thinning behaviour that can be well predicted by the Cross model. The higher the concentration of starch in the sample, the higher the magnitude of zero viscosity, more gel like behaviour and the better the strength of the gel. Freeze thaw stability of sago starch can be improved by adding a small amount of biopolymer. This can still be economical considering the low price of sago starch.

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