

## Effect of temperature and pH on viscosity of pineapple gum

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### Abstract

Research on gum derived from local fruits is actively being carried out for food industrial applications. However, limited study has been conducted to look at the processing parameters on the properties and quality of the gum. This study was conducted to assess the effect of temperature and pH on viscosity of pineapple gum solution. A 1% pineapple gum solution was prepared and the viscosity was measured at different temperatures (10, 30, 40, 50 and 70 °C) and pH (2, 5, 6, 7, 8, 9 and 10). Viscosity of 1% pineapple gum solution was found to be 8.80 CPs at room temperature. Increase of temperature from 10 – 70 °C resulted in decreasing viscosity up to 56%. The pH value of 1% pineapple gum solution at room temperature was 6.76. The highest pineapple gum viscosity was observed at pH 10 with value of 6.00 CPs. It was found that the viscosity of pineapple gum significantly decreased at more acidic condition. Generally, pineapple gum solution was fairly stable over a wide range of pH between 2 and 10 and revealed that the gum can be incorporated in various food products within the pH range.

Keywords: *Ananas comosus*, pineapple gum, viscosity, sugar profiling, molecule structure

### Introduction

Pineapple (*Ananas comosus*) is a tropical plant with edible multiple fruit consisting of coalesced berries and available in different types of varieties. Pineapple has been reported to contain gum which contributes to the viscosity, suspension of solids and foaming of pineapple juice (Chenchin and Yamamoto 1978; Dull 1988). Grassin and Fauquembergue (1996) revealed that pineapple gum contains 70% sugars and predominantly found as galactomannan where the ratio of mannose:galactose is 2.25:1.

Generally, the function of gums can be limited to two major properties which are gelling and thickening (Glicksman 1969). In food, gums are used in a wide range of

specific food applications, ranging from adhesives to whipping agents. Currently, food gums from plants, such as guar, acacia and locust bean, are widely used in food industry due to their ability to thicken and stabilise many food products (Stephen and Churns 1995).

There are some other food gums derived by microbial fermentation like xanthan gums and chemically synthesised, such as cellulose gums. Gums derived from animal tissue such as gelatin (Anon. 2007) are quite controversial among certain groups of consumers such as vegetarians, Moslem and Kosher. Therefore, gums from plant based are more preferred by food manufacturer. Hence, gum from local pineapple should be explored as

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this polysaccharide has a potential to be a thickening or gelling agent besides having beneficial health properties and yet can add value to the local pineapple variety.

All gums or hydrocolloids, by definition and usage have a thickening or viscosity-producing effect when dispersed in a water medium. This property is the basis for their use as bodying, stabilising and emulsifying agents in many foods. Reduction in the viscosity of polymer solutions may impair the flow properties and appearance of the product sufficiently to reduce its consumer acceptability (Glicksman 1969). Viscosity is the resistance to flow of a liquid system. It is the most common way of characterising a liquid or fluid material which is actually a measure of fluid friction. The importance of viscosity could be seen in textural quality and consistency of most foods.

The viscosity of gum systems are affected by many factors. They may include temperature and pH. The ability of gums to increase viscosity or to thicken the aqueous system is the most important property of the gums (Hui 2006). Therefore, this study was aimed to assess the effect of temperature and pH on viscosity of pineapple gum solution. Sugar composition and molecular structure of the gum extracted from pineapple were also determined. A more complete understanding of the properties and structure of pineapple gums will shed light on the structural origin of its properties and aid in the eventual utilisation of pineapple gum in the food industry.

### Materials and methods

Local pineapple fruit (Josapine variety) was purchased from wholesale market, Seri Kembangan, Selangor. Commercial locust bean gum from Sigma-Aldrich (St. Louis, USA) was used as a control. Sugar standards (arabinose, galactose, mannose, fructose, glucose and rhamnose) were purchased from Sigma-Aldrich (St. Louis, USA). All chemicals used were of analytical grade unless otherwise specified.

A sample of 20 g Josapine gum was extracted using Azero and Andrade (2002) method with a slight modification. The fruit was washed using filtered tap water and the skin was peeled. The flesh was sliced manually and dried in a forced-draft oven (Memmert, Germany) at 55 °C. The dried samples were milled into flour using grinder (Toshiba, Japan). Extraction of pineapple gum was done by soaking the pineapple flour in water overnight at room temperature. The supernatant was collected by filtration and centrifugation at speed of 9,000 rpm for 15 min at 25 °C using a centrifuge (Zentrifugen, Germany). The clear solution of supernatant was collected and neutralised with sodium hydroxide followed by precipitation with 95% ethanol. The precipitate, which is the crude gum, was collected, washed with ethanol and oven dried at 45 °C.

A 1% solution of pineapple gum (JG) was prepared by dissolving dried gum powder in water at room temperature, which was then agitated vigorously until the solution became viscous and homogenous (Amin et al. 2007). Locust bean gum (LBG) was prepared in the same manner and used as a control.

The viscosities of JG and LBG were measured using a Brookfield digital viscometer, model RVT DV-II using spindle number 1. To determine the effect of temperature on viscosity of JG and LBG solutions, the spindle speeds used were 20 rpm and 25 rpm respectively. The viscosities of the two gum solutions were measured at 10, 30, 40, 50 and 70 °C at a constant pH of 6.7 and 4.1 for JG and LBG respectively. The temperature was maintained by placing the beaker containing gum solutions on a heater while measuring the viscosity.

To measure the viscosity at different pHs, the temperature was held constant at room temperature between 27 and 28 °C. pH of 1% solution of JG and LBG at room temperature were 6.7 and 4.1 respectively. The pH of the gum solutions

were adjusted with HCl and NaOH to values of 2, 5, 6, 7, 8, 9 and 10 (Amin et al. 2007). The pH of gum solutions was measured using a 744 pH meter (Methrom, Switzerland) with pH 4.0 and 7.0 buffers for calibration. All measurements were done in three replications.

Samples of pure JG and LBG were prepared according to Amin et al. (2007). A Waters HPLC unit and Alltech prevail carbohydrate ES column, 250 mm x 4.6 mm ID (5  $\mu$ m) was used to determine the sugar composition. The mobile phase was 80/20 acetonitrile-water at 30 °C. Evaporate Light Scattering Detector (ELSD) was used with flow rate of 1.0 ml/min. All chemicals used are of HPLC grade. Results obtained were compared with known sugar standards.

The surface morphology of JG powder was evaluated using a scanning electron microscopy (SEM). The powder samples were attached to a double-sided adhesive tape mounted on SEM stubs. The powders were sputter coated with a thin layer of gold under vacuum since the powder is not conductive (Tonon et al. 2008). SEM utilises vacuum conditions and use electrons to form an image. Scanning electron micrographs were examined using a Leo Scanning Electron Microscope (Leo 1455 variable pressure SEM, Germany) at an accelerating voltage of 20 kV with magnifications of 5000x.

### Statistical analysis

All the physical data were recorded in triplicate. These data were analysed using the MINITAB software version 14 for ANOVA.

## Results and discussion

### Effect of temperature on viscosity

Viscosity of 1% JG solution was 8.80 CPs at room temperature. The viscosity of JG was significantly ( $p < 0.05$ ) lower (19 times lower) than that of LBG (Figure 1). The viscosity of JG varied directly with changes in temperature over a range of 10 – 70 °C. A similar result was also found in 1%

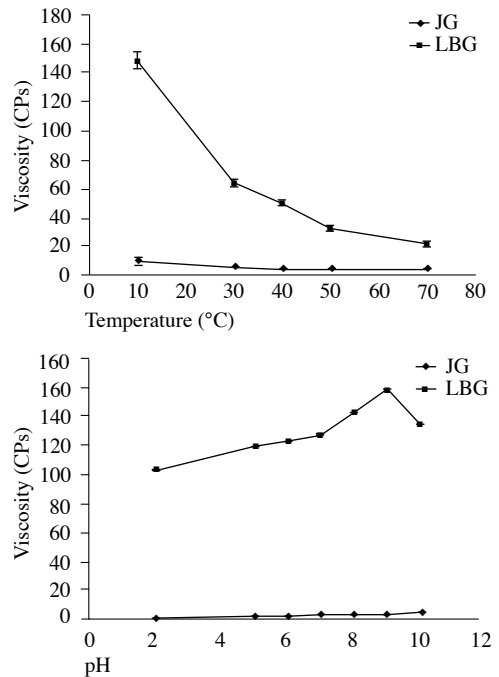


Figure 1. Viscosity of Josapine and locust bean gum at different temperatures and pH ( $p < 0.05$ )

LBG solution. An increase of temperature from 10 to 70 °C caused a viscosity of JG to decrease about 56% and it was lower compared to LBG which decreased to about 85%.

According to Wielinga (2000) and Hui (2006), the viscosity of most gum solutions decreases with increase in temperature, although some gums are more resistant to temperature changes. Singh et al. (2002; 2003) and Amin et al. (2007) reported that the viscosity of durian, *Ipomoea turpethum* and *Ipomoea campanulata* seed gum solutions decreases as temperature increases. Decreasing in viscosity of the gum solutions with increasing temperature is due to the increase in macromolecular motion and solubilisation of gum solution at higher temperature (Samil Kök et al. 1999). Most gums have long-chain polymers and it is suggested that JG might be such a gum and subject to molecular breakdown caused by cleavage of molecular bonds, resulting in lower viscosities.

In addition, smaller hydrodynamic volumes of the highly branched polysaccharides may cause low viscosity of gum solution (Hui 2006). Gum with low molecular weight due to the long-chain polymers effect from a thermal degradation also contribute to the loss of viscosity. The result showed an advantage to Josapine gum because generally, the low-viscosity natural gums are more stable compared to the high-viscosity types (Glicksman 1969).

### **Effect of pH on viscosity**

The pH value of 1% JG solution at room temperature was 6.76 and for LBG was 4.07 (Figure 1). The pH value of JG solution was similar to *Cassia angustifolia* seed gum (6.0 – 7.0), *Cassia grandis* seed gum (6.0 – 7.0), durian seed gum (6.93) and guar gum (5.5 – 8.0) (Chaubey and Kapoor 2001; Joshi and Kapoor 2003; Amin et al. 2007). Changes in pH influenced the viscosity of JG. A similar result also found on LBG. The viscosity of JG significantly ( $p < 0.05$ ) decreased gradually at more acidic conditions. Viscosity was significantly ( $p < 0.05$ ) higher at alkaline conditions which were at pH 10.0 and 9.0 for JG and LBG respectively.

According to Williams and Philips (2000), galactomannan can degrade and lose its viscosity at high and low pH. Furthermore, Wielinga (2000) reported that viscosity of 1% guar gum solution decreases below and above pH 7.0. This probably because of a partial depolymerisation of the galactomannan molecule (Gastón Eduardo 1963) causing the viscosity to lose. This study showed that pineapple gum solution was fairly stable over a wide range of pH between 2.0 and 10.0 at room temperature. Hence, JG can be incorporated in all types of food products within pH 2.0 to 10.0.

### **Sugar composition**

The presence of six sugar components in JG namely rhamnose, arabinose, fructose, mannose, glucose and galactose was established by comparison of relative

retention times of known standards using HPLC. Quantitative analysis showed that galactose (29.1%) was the highest monosaccharide followed by arabinose, glucose, fructose, mannose and rhamnose (Table 1). Sugar analysis of LBG revealed that this gum was purely a galactomannan gum. LBG contained two types of sugar, which were galactose (27.7%) and mannose (72.3%).

Findings on sugar composition of JG were in agreement with Chenchin and Yamamoto (1978) who also reported the sugar compound in pineapple gum with an exception of rhamnose and fructose. They reported the presence of five sugars namely arabinose, glucose, galactose, mannose and xylose where mannose was the predominant monosaccharide with 48.2% from sugars hydrolysate followed by 21.4% of galactose. It was suggested that differences in sugar composition among pineapple gums might be due to the different variety, soil and ergonomic conditions. Andersen and Wang (1991) indicated that the sugar composition in plants are affected substantially by the soil in which the plants are grown.

### **Particle morphology**

Figure 2 shows scanning electron micrograph (SEM) of JG. The particle structure of the gums was sphere in shape and each particle was closely attached to each other. The sphere shape might increase the surface area of the particle and also increase the capacity of water retention. It is, therefore, contributed to the ability

Table 1. Quantitative determination of sugar components in Josapine gum hydrolysate by HPLC

Sugar	% of gum hydrolysate
Galactose	29.13 ± 1.85
Arabinose	26.12 ± 1.54
Glucose	13.68 ± 0.56
Fructose	11.74 ± 0.03
Mannose	11.59 ± 0.33
Rhamnose	7.73 ± 0.15

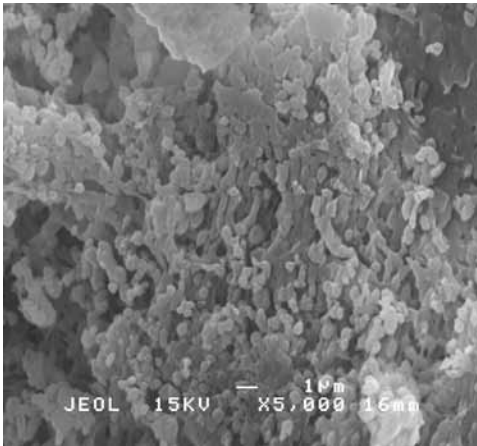


Figure 2. Scanning electron microscopy (SEM) microphotographs of Josapine gum (5000x magnification)

of the gum to absorb water, hence, would also increase the viscosity ability of JG. There are hollows at certain part of the gums particles. This could be resulted from grinding process that lead to rupture in matrix structure. The sphere structure of JG is similar with guar gum (Wang et al. 2003) but different with xanthan gum which is polyhedral in shape with wrinkled surface (Ahuja et al. 2012).

### Conclusion

Changes in temperature and pH showed a significant influence on the viscosity of pineapple gum. There was a great difference in the magnitude of viscosity of pineapple gum compared to commercial gum. Pineapple gum can be categorised as a stable gum as the viscosity of the gum was maintained between pH 2.0 and 10.0 at room temperature and very soluble natural gum due to its low viscosity. It is suggested that pineapple gum might be incorporated in a wide range of food product within the pH range. This implies that pineapple gum might be of interest for food industry, considering its potential application as food ingredient in confectionery, bakery products or in beverages.

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### Abstrak

Kajian berkaitan gam daripada buah-buahan tempatan semakin berkembang pesat bagi kegunaan dalam industri makanan. Kajian yang dilakukan terhadap parameter pemprosesan ke atas ciri-ciri dan kualiti gam adalah terhad. Kajian ini dilaksanakan untuk menilai kesan suhu dan pH ke atas kepekatan larutan gam nanas. Satu peratus larutan gam nanas disediakan dan kepekataannya diukur pada suhu (10, 30, 40, 50 and 70  C) dan pH (2, 5, 6, 7, 8, 9 and 10) yang berlainan. Kepekatan 1% larutan gam nanas ialah 8.80 CPs pada suhu bilik. Peningkatan suhu daripada 10 hingga 70  C menyebabkan penurunan kepekatan sebanyak 56%. pH 1% larutan gam nanas pada suhu bilik ialah 6.76. Kepekatan gam nanas adalah tertinggi pada pH 10 dengan 6.00 CPs. Didapati kepekatan gam nanas menurun secara signifikan pada keadaan berasid. Secara keseluruhan, larutan gam nanas adalah stabil pada pH antara 2 hingga 10 dan ini menunjukkan bahawa gam nanas boleh diguna pakai dalam pelbagai jenis produk makanan yang mempunyai julat pH tersebut.