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Rheological properties of cashew gum

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Solubilities and rheological properties of dissolved fractions of cashew gum from *Anacardium occidentale* were investigated. A fraction of gum (64.2%) dissolved in water at 30°C. A further 13.4% dissolved when the remaining suspension was heated. The fraction that dissolved at 30°C produced greater solution viscosity than the other fraction or the whole gum. When the pH was raised above 5.5, the solution viscosity dropped sharply. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Cashew gum is a bark exudate of *Anacardium occidentale*, a tree that grows wild in many tropical and subtropical countries. The tree is known for its nuts, used as a food ingredient, especially in oriental delicacies. Although cashew gum has not found many industrial uses, its application in the field of pharmacy has been described (Howes, 1949; Smith & Montgomery, 1959). Current interests in *A. occidentale* are, however, in the various extracts from other parts of the plants, especially the fruit juice and nutshell liquid which have been reported to show breast antitumor activity (e.g. Kubo *et al.*, 1993; Toyomizu *et al.*, 1993). The gum is a complex polysaccharide, comprising 61% galactose, 14% arabinose, 7% rhamnose, 8% glucose, 5% glucuronic acid and <2% other sugar residues. It has a highly branched galactan framework consisting of chains of (1→3)-linked β-D-galactopyranosyl units with interspersed β(1→6) linkages. The main aldobiouronic acid present is 6-*O*-(β-D-glucopyranosyluronic acid)-D-galactose (Bose & Biswas, 1970; Anderson *et al.*, 1974; Anderson & Bell, 1975). Since it is soluble in water, its further characterization was desirable, with a view to incorporating it in porous films or beads in combination with chitin and chitosan, which are currently studied in our laboratory for agricultural applications. The present communication focuses on the rheological properties of cashew gum.

MATERIALS AND METHODS

Materials

Samples of gum were collected from trees grown on the cast coast of Peninsular Malaysia. No details of the botanical aspects of the species were noted. The tears were somewhat contaminated with bark and were colourless to light amber in colour. Samples were ground to pass through a 2.5 mm sieve. Moisture contents were determined by drying overnight at 105°C to constant weight.

Determination of solubility

Dried gum (10 g) was stirred in distilled water (250 ml) for 2–3 h at room temperature (RT). A supernatant was obtained by centrifugation. The residue was washed with water and the washing was added to the separated supernatant. The procedure was repeated twice more. Finally, the supernatant was made up to 500 ml. Triplicate 10 ml aliquots were dried at 105°C to determine the amount of dissolved solid. The residue was treated similarly, but heated with stirring in a hot water bath of 90–95°C. The amount of dissolved solid obtained via this treatment was termed 'dispersible fraction' since it could be dissolved only at an elevated temperature. When the whole gum was extracted at the elevated temperature, the dissolved solid obtained was referred to as 'whole gum'. Ash content was determined on the whole gum by heating triplicate 10 ml aliquots to 650–700°C overnight in a platinum dish to constant weight, followed by cooling in a desiccator before weighing.

Measurement of viscosities

Viscosities were measured on a Haake Rotovisko RV3 using an NV sensor head and two torsion springs of DMK 50 and DMK 500 g cm. Shear stress, τ (dyne cm^{-2}), and shear rate, D (s^{-1}), were read from the instrument to calculate the viscosities, η (cps), as the ratio of τ/D. All concentrations of the solutions for viscosity measurement were determined by the evaporation of triplicate aliquots, including the diluted solutions. When desired, pH was adjusted by addition of 1 M HCl or 1 M NaOH prior to concentration determination. All measurements were made at RT 30±2°C.

RESULTS AND DISCUSSION

Solubilities

The average moisture content of the samples was 17.2%. The solubility of cashew gum is shown in Table 1. Typically 64.2% of gum dissolved in water to give a stable solution (soluble fraction). A further 13.4% could be dispersed in hot water to form a stable dispersion (dispersible fraction). Thus a total fraction of 77.6% of the gum (whole gum) could be dissolved or dispersed in water. The gum has an average ash content of 7.4%. Self-association is a known characteristic of cashew gum (Anderson *et al.*, 1974) and could be related to a fraction being only soluble in hot water. Divalent ion crosslinking as occurs with gum ghatti (Jefferies *et al.*, 1978) could be another reason.

Rheological properties

The flow characteristics of the soluble fraction, the dispersible fraction and the whole gum are shown in Fig. 1. All fractions showed pseudoplastic non-Newtonian flow, characteristic of many polysaccharides. Solutions of the soluble fraction appeared to be more pseudoplastic than solutions of the dispersible fraction or the whole gum. Figure 2 shows the dependence of viscosity on concentration. The soluble fraction had the highest viscosity range. The whole gum and the dispersible fraction produced similar viscosity ranges. This is in contrast to gum ghatti, in which the soluble fraction has lower viscosity compared to the dispersible fraction, which was thought to contain more calcium and magnesium ions (Jefferies *et al.*, 1978). Solutions of cashew gum show lower viscosity than most of the common gums such as arabic and tragacanth. For example, a 5% solution of gum arabic and gum tragacanth has a viscosity of 7.25 and 111,000 cps, respectively (measured on a Brockfield viscometer at 25°C) (Glicksman, 1969; Glicksman & Sand, 1973), whereas the viscosity of cashew gum of similar concentration measured in this work is *c.* 2 cps. Gum arabic is known for its high solubility but low viscosity; at concentrations of up to 40%, solutions of gum arabic still exhibit Newtonian behaviour. Despite the low viscosities, solu-

Table 1. Solubilities of cashew gum[a] in water (% w/w)[b]

Soluble fraction	64.2
Dispersible fraction	13.4
Debris	21.9

[a]17.2% moisture, 7.4% ash.
[b]Dry weight basis.

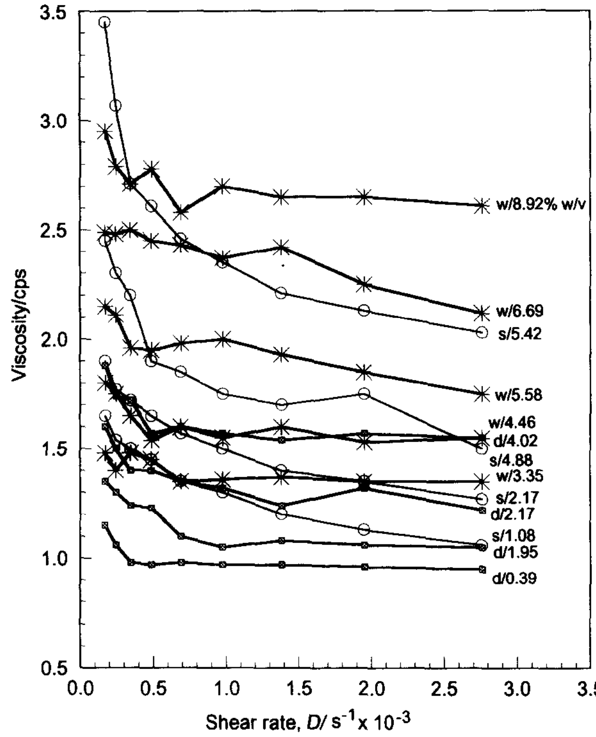

Fig. 1. The flow characteristics of fractions of cashew gum at various concentrations. s, soluble fraction (○); d, dispersible fraction (■); w, whole gum (*).

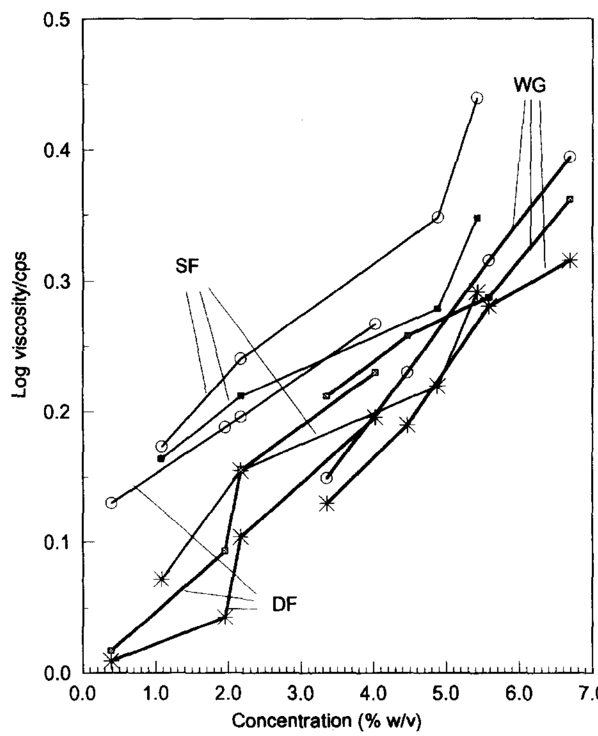

Fig. 2. Viscosities of fractions of cashew gum with concentrations at various shear rates: 340 (○), 1360 (■) and 3900 s^{-1} (*). SF, soluble fraction; DF, dispersible fraction; WG, whole gum.

tions of cashew gum, in contrast to gum arabic, exhibit non-Newtonian behaviour at concentrations even less than 1%, with shear rate independence being shown only for *D* more than *c.* 10^3 s^{-1} (see Fig. 1).

The application of heat while stirring to dissolve cashew gum, although it increases the amount of gum dispersed, appears to lead to the lower viscosity. Since all fractions exhibit similar viscosity ranges at high shear rates (Fig. 2), the difference in the viscosity range at lower shear rates may be attributable to the difference in the size of the molecule, rather than to the detail of structures. The heat applied also may have degraded the molecules by hydrolysis, or by simply disrupting physical entanglements or interactions natural in the gum, as observed in gum arabic (Whistler & Smart, 1953).

The effect of pH on rheological properties

The pH of 5% w/v cashew gum solution was 4.4–4.8. The plot of viscosity vs solution pH is shown in Fig. 3. In the acidic region, the solution was light yellow; it changed to yellowish-brown in the alkaline region. Maximum viscosity is produced below pH 5, i.e. in the natural pH range. In the alkaline regions the solution viscosity dropped sharply, with reductions of more than 50%. This phenomenon is a well-known characteristic of most gum solutions (Glicksman, 1969). At low pH, the polymer chains are presumed to be in the coil state because the acidic components exist in free acid form. As the pH is raised, the components began to ionize, the coils expand because of charge repulsion, causing the viscosities to increase. The viscosities will be maximum when the chains are in a state closest to the rod conformation and in the cashew gum solution; this presumably occurs in the vicinity of natural pH where ionic species are not operating. In the alkaline region, in the presence of the added alkali, screening effects cause the viscosities to decrease.

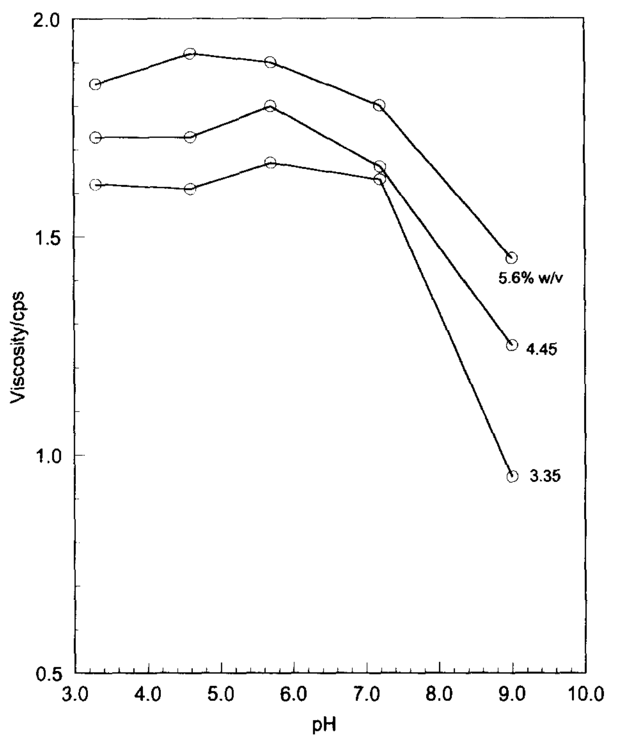

Fig. 3. The effect of pH on the viscosities of cashew gum at the concentrations indicated.

CONCLUSIONS

Application of heat during dissolution of cashew gum increases its solubility in water from 64.2 to 77.6%. However, the viscosities of the gum solution obtained by heat treatment are lower. Addition of acid and alkali also reduce the viscosities. From all the investigated factors, one may conclude that the molecular dimension and conformation caused by various interactions play a dominant role in the solubility and viscosity properties of cashew gum aqueous solutions.

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