African Journal of Food Science Vol. 5(4), pp. 188 - 193, April 2011
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 ©2011 Academic Journals

Full Length Research Paper

Rheological, moisture and ash content analyses of a gum resin from *Commiphora Africana*

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Accepted 17 January, 2011

A gum resin was isolated from *Commiphora africana.* In order to assess its application to industry, it was subjected to rheological, moisture and ash content studies. For rheological studies, a rotational viscometer which had the ability to characterize both Newtonian and non-Newtonian systems was used. The gum resins from *C. africana* exhibited low shear stress even at high concentration of the gum resins. The change in shear stress with temperatures produced almost a linear graph with a gradient of 0.06. In addition, the gum resin from this plant species was affected by the addition of salts and would have little application in formulations that contain salts. The moisture content obtained was 10.6 ±0.04%.The low level of moisture in this gum resin appeared to be desirable since it will attract little bacterial or fungal growth in the formulation. The ash content was 3.64±0.01%. The present study has demonstrated that this gum has potential as a product for the cosmetic, pharmaceutical and food industries provided further studies are carried out to identify the phytoconstituents in the gum as well as toxicity studies.

Key words: *Commiphora Africana,* gum, rheology, moisture, shear stress, ash content, pharmaceuticals, food industry.

INTRODUCTION

Commiphora africana belongs to the family of Burseraceae. Its common name is poison-grub commiphora. It is a shrub to small tree 2 to 5 m in height occurring at medium to low altitudes in dry types of woodland and bush, often among rocks (Arnold and Dewet, 1993). This species has been divided into two varieties. The typical variety, var. Africana, has the calyx and the flower stalks completely without hairs, while *var. rubriflora* (Engl.) Wild has the calyx and the flower stalks covered with velvety hairs, and its leaves and stems are more densely hairy. The typical variety is the one most often encountered in South Africa, although one record of *var. rubriflora* is known from the Soutpansberg. The washed bark mixed with salt is applied to snakebites, and the fruit provides a remedy for stomach ailments (Paraskeva et

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al., 2008). The soft, sappy wood and clean stems are employed by Africans in the construction of drop-traps for leopards and lions, while the trees are widely used as live fences.

C. africana is a common plant in Africa and has been found to possess several activities. Previous studies on *C. Africana* have shown that this plant may be a very good source of analgesic (Ezekiel et al., 2010). Elsewhere, it was also shown that this plant has antilipidaemic properties and could be used in the management of cardiovascular disorders (Adebayo et al., 2006). *C. africana* extract may also enhance liver function at low doses and may cause adverse effects at high doses (Aliyu et al., 2007). The larva of the beetle *Diamphidia*, from which Bushmen make their arrow poison, feeds exclusively on these trees (Palgrave, 1984). The gum and resin which exude from the tree are made into a plaster which is applied in cases of abdominal spasms and to the head in cases of fever; it is sometimes mixed with fat and used as a perfumed body lotion and is also considered to be a good insecticide, especially against termites.

Gums are polysaccharide complexes formed from monosaccharide and uronic acid units (Trease and Evans, 1985). The polymers are insoluble in alcohol but usually dissolve or swell in water to form viscous solutions. Many gums are not formed by the plant until it has been injured. Therefore most of the gums are of pathological origin.

Usually gums are found to be associated with resins (Riedo et al., 2010). The term resin is applied to more or less amorphous products of complex chemical nature. Gums are used in the production of binding agents in pills and tablets (Kumar and Singh, 2010). Some gums such as Sterculia (*Karaya gum*) are used in the USA and France as bulk laxatives. Powdered forms of some of these gums are used in pastes and denture fixative powders. They are particularly useful as adhesives for stoma appliances. Gums and resins are employed in the textile industry as dye carriers. For example, gum Arabic is used as a general stabilizer in emulsions and as a pharmaceutical component in lozenges. The demulcent properties of Gum Arabic are employed in various cough, diarrhea and throat preparations (Owusu et al., 2005). Other gums such as Guar gum and Tragacanth are used as suspending agents for insoluble powders in pharmaceutical suspensions. Pectin is an example of a gum used as a gelling agent. There is no literature documentation with regard to the use of *C. africana* gum in the pharmaceutical industry and yet the cost of drugs is ever escalating in developing countries. One reason for this high cost of drugs is that in addition to drugs proper, most of the excipients necessary for the formulation and production of pharmaceuticals are imported at high cost. In order to solve this problem, it would be useful to search for suitable, cheap and locally available substitutes. Gums are some of the commonly used products in the manufacturing of cosmetics, food and pharmaceuticals. The subject of this paper is therefore, to determine the suitability of *C. africana* gum resin in pharmaceutical, cosmetics and food industries.

MATERIALS AND METHODS

Collection and preparation

Some gums exude from trees as a result of the natural cracking of the bark. This was the same with the gum from *Commiphora africana* and hence the gum was simply collected in plastic bags and stored in a dry oven waiting for testing. The plant was collected from Bikita District of Zimbabwe in February 2006, with the authorization of the Zimbabwean Government and in agreement with the United Nation Convention on Biodiversity. The plant was identified by botanists at the National Herbarium and Botanic Gardens in Harare, Zimbabwe. Three voucher specimens were deposited at the National Herbarium and Botanic Gardens in Harare, Zimbabwe (Reference number: 01/MG/1089). One specimen was deposited in the Herbarium of the Department of Pharmacy at the University of Zimbabwe. A total amount of 560 g of gum was collected for analysis from about seven different trees.

Moisture content

Three samples of the gum were placed in watch glasses and weighed on an Avery laboratory balance. The samples were placed in an oven with a preset temperature of 50°C. After every 10 minutes interval the gum samples were taken out and weighed again. This was repeatedly done until the weight of the samples remained constant. The percentage of the moisture in the gum was then calculated as previously described by Moreno et al., 2000).

Ash value measurement

Three samples of the gum were placed in pre-weighed crucibles and weighed. These were then placed in a preheated furnace set at 300°C for 3 h. The temperature of the furnace was then elevated to 600°C until the charred gum samples were ash white.

Care was taken that no black or grey specks remained conspicuous in the resulting ash. One hour was required for this process. Samples were then taken out using a pair of tongs and allowed to cool down in a dessicator. After cooling, the crucibles containing the samples were weighed again. The ash value was obtained by subtracting the combined weight of the ash samples and crucibles from the combined weight of the fresh samples and crucibles (Moreno et al., 2000).

Rheological tests

Rheology is the study of flow of materials (Marriot and Aulton, 1993). A very important parameter in the study of flow properties is viscosity described as a measure of a fluid's resistance to flow (Harding, 1979). These properties are very important in any liquid drug, cosmetic and food preparations.

Change in shear stress with shear rate

Preparation of samples

The samples were prepared by suspending 66 g of the gum in 100 ml distilled water at about 60°C in a 250 ml beaker. After vigorous agitation to dissolve the gum, more water was added to give a final volume of 200 ml. This gave a 33% w/v solution.

Measurement of shear stress

The prepared solution was placed under a Schott Iberica, S.A. 18549 rotational viscometer fitted with the correct spindle size appropriate for the solution's apparent thickness. The lowest shear rate was then selected, that is, 0.3 revolutions per minute.

The spindle was dipped into the gum solution to the appropriate depth. The viscometer was then started. After noting the shear stress reading, the shear rate was then increased to the next programmed speed and the process above repeated. Shear rate was thus increased until the maximum speed was attained at 100 revolutions per minute (r.p.m). All the measurements were carried out at room temperature (Owusu et al., 2005).

Operating conditions

The temperature of the solutions was kept at room temperature (25°C). The solution concentrations were standardized at 33% w/v. Only the shear rates that were pre-programmed in the viscometer were used and these ranged form 0.3 r.p.m. to 100 r.p.m. Spindle sizes were selected according to the apparent thickness of the solution which was confirmed by the absence of the viscometer's acoustic alarm bell for wrong spindle size. A graph of shear stress versus shear rate was then plotted as previously described (Dlamini et al., 2007).

Change in shear stress with temperature

A gum sample of 2 g from the plant was weighed on a balance. The sample was transferred to a 250 ml beaker and distilled water was added. The resulting mixture was then stirred vigorously using a glass rod until all the gum had dissolved. This solution was then made up to the 200 ml mark with more distilled water to produce a 1% w/v solution. The solution was then placed in a small water bath and then transferred to a refrigerator. Periodic temperature readings were taken using a thermometer. When the solution had reached 4°C, it was taken out for shear stress measurements at 30 rpm.

Following shear stress measurement, the gum solution and the small water bath were then warmed to 10°C by leaving them on a bench top. Shear stress measurements were carried out as above. The same procedure was repeated at 25°C. To warm the gum solutions to 40, 60 and 89°C, the large automated and temperature controlled Unitronic 200 water bath from J.P Selecta was used. The small water bath was also warmed to maintain the gum solution at desired temperatures whilst shear stress measurements were being carried out. A graph of shear stress versus temperature was plotted (Owusu et al., 2005).

Change in shear stress with gum concentration

Solutions of the gum resin at various concentrations were prepared. For a given concentration of gum resin, a corresponding weight was calculated using the following formula:

Required weight = Concentration × Volume

The solution was prepared by weighing the required amount of the gum sample into a beaker. Distilled water was added to dis-solve the gum. The resulting solution was then made up to the 200 ml mark by adding more distilled water. Using this procedure, the solutions at concentrations up to 33% were prepared. The shear stress of the resulting solutions was determined at 30 rpm at room temperature. R2 spindle size was used.

The following concentrations were investigated: 0.25, 0.5, 0.75, 1, 2, 2.5, 5, 10, 20 and 33% w/v. All the shear stress measurements were carried out at room temperature. A graph of shear stress versus gum concentration was then plotted.

Change in shear stress with added ion concentration

A 1% w/v solution of gum was prepared. The mass of calcium chloride necessary to make a 0.1% w/v solution was added to solu-tions of the gum and stirred. Because calcium chloride powder is hygroscopic, care was taken to weigh it as quickly as possible. The shear stress of the resulting gum solution was then determined at 30 r.p.m. The shear stress determinations were carried out a room temperature. The shear stresses of the resulting solutions were measured and recorded. These measurements were carried out at room temperature. The spindle size was R2 throughout. A graph of shear stress versus ion concentration was plotted (Flatt et al., 1992).

RESULTS AND DISCUSSION

The moisture content from the gum resin was 10.6±0.04% while the ash content from the gum resin was 3.64±0.01%. Ash content is important in some preparations (Ozcan et al., 2007). When gums are inci-nerated, they leave inorganic ash which in some cases varies within fairly wide limits. In many cases the total ash figure is within a characteristic narrow range and can be a useful characterization tool (Adikwu et al., 2001). The ash usually consists mainly of carbonates, phosphates, silicates and silica (Aziznia et al., 2008). This parameter gives an indication of the degree of mineral interaction in the structure and thus properties of the polysaccharides. *C. africana* had low ash content of 3.64±0.01%. Ash content has been reported to be an important property and could be considered as purity in parameter in gums (Glicksman, 1969).

The very low values of ash show that cashew gum has a good quality of mineral content the same as found in the present study of *C. africana* gum. This can be used as a parameter for quality control of the gum resin described in the present study. The level of moisture in the gum resin from *C. africana* makes the gum suitable for formulations that need high moisture content. In fact depending on the temperature, the moisture of a mixture could lead to the activation of enzymes and the potential proliferation of micro-organisms which might affect the shelf life of the mixture (Zaku et al., 2009). Therefore it is important to investigate the moisture content of potential pharmaceutical materials since its economic importance for industrial application will depend on the optimization of production processes such as drying, packaging and storage.

As shown in Figure 1, the change in shear stress with shear rate was non-linear. This is a non-Newtonian

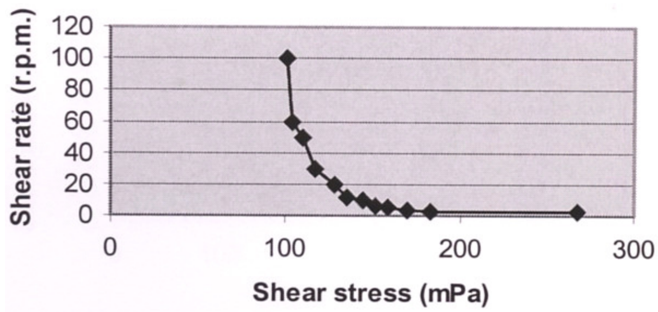

Figure 1. Change in shear stress with shear rate.

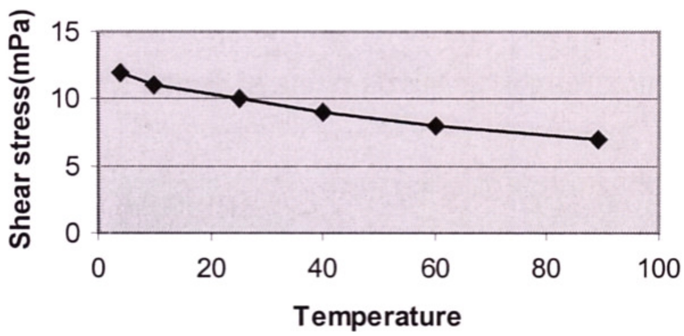

Figure 2. Change in shear stress with temperature.

behaviour. This property is also manifested by pseudoplastic materials (Berg et al., 2003; Sharma et al., 2010). The gum displayed a progressive reduction in viscosity as the rate of shear was increased. This is also found in tomato sauce which cannot easily be poured out of the bottle on merely tilting the container.

However, on shaking the bottle (shearing) the sauce is easily poured out as its viscosity falls and flow is improved. Pharmaceutical materials that have a non-Newtonian behaviour include Tragacanth gum. The presence of high molecular weight molecules in solutions results in entanglement with immobilized solvent molecules. Under the influence of shear, the molecules tend to become disentangled and align themselves in the direction of flow and this together with the release of the entrapped water accounts for reduced viscosity. This gum if studied further to address the problems of toxicity and to elucidate the structures of chemicals in the gum resin, can be used as a substitute for Gum tragacanth.

The relationship between shear stress and temperature was non-linear. As shown in Figure 2, there was a gradual fall in shear stress with increase in temperature. This rheological character with changing temperature is important in the food industry for added polymeric ingredients such as gums and gum resins (Moreno et al., 2000). In the same light, other authors have indicated that the viscosity decreases with increase in temperature (Alakali et al., 2003). Such behaviour is said to be due to its system of binding and similar characteristics have been observed with certain foods. It has been suggested that knowledge of the rheological characteristics of food gum at different temperatures is crucial for effective design and simulation of its momentum transfer process and system (Dakia et al., 2008). In fact, rheological data are important in food processing for several reasons such as the design of process equipment like pumps, pipes and mixers; determination of the ingredient function in a formulation and the control of intermediate and end products (Dogan and Kavacier, 2004). For example in the manufacture of packages and consumption of ice-cream, the rheology of the polymeric thickening agents at various temperatures is a major concern. Substantial viscosity change with temperature as occurred with the gum from *C. africana* is desirable. At low temperatures, these polymers will stabilize the structure of the ice cream but will 'melt in the mouth' when the temperature is higher. This property may render this gum resin useful in the preparation of some food, cosmetic and pharmaceutical products.

Change in shear stress with gum concentration is important for gums. The results of the present study indicate that as concentration of the gum increased, there was a relative rise in shear stress (Figure 3). Gums that exhibit low shear stress even at high concentrations are used as emulsion stabilizers for example Gum Arabic. Similar behaviour was described for gum exudates from

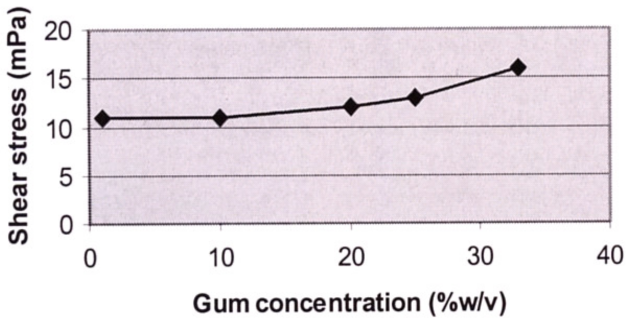

Figure 3. Change in shear stress with concentration of gum.

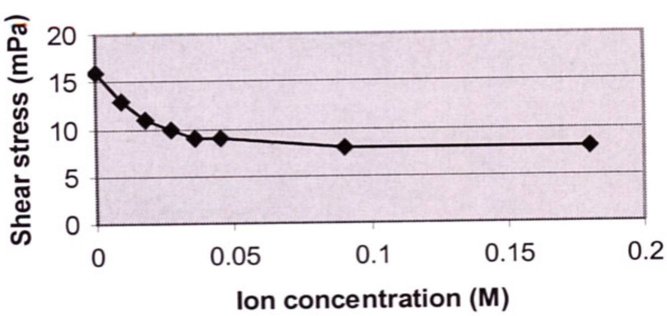

Figure 4. Change in shear stress with concentration of added ion ($CaCl_2$).

Ocimum basilicum where the flow behaviour of 1% basil seed gum indicated a higher viscosity of this gum at low shear rates compared to xanthan, konjac and guar gum at similar concentration (Hoseini-Parvar et al., 2010). The gum from *C. africana* exhibited large shear stresses even at relatively low concentration of gum, a feature that is seen in polymers such as Guar gum and carboxy-methylcellulose that are used as thickening agents.

Plots of shear stress with added ion concentration show that the polymer's shear stresses are reduced by addition of ions (calcium chloride) until a certain minimum value of shear stress is reached. As shown in Figure 4, there was significant effect of ion concentration on shear stress. As the ion concentration increased, the shear stress likewise decreased.

The gum from *C. africana* was significantly affected and could be used in formulations containing low concentrations of salts. The plots of shear stress versus added ion concentration showed that the gum's shear stresses are reduced by addition of ions (calcium chloride) until a certain minimum value of shear stress is reached. The gum from *C. africana* was significantly affected by addition of ions and would have little applications in applications in formulations that contain salts. In a study by Dlamini et al. (2007), salt concentration did not affect the solubility of *K. oxytoca* polysaccharide but decreased viscosity. In this study, the apparent viscosity of the exopolysaccharide decreased at salt concentrations, to at least 50% of solutions with no salts. In response to this it was suggested that this behaviour could be attributed to the contraction of the polysaccharide chain as a result of electrolyte-induced charge shielding thereby reducing the repulsion between anionic substituents within the chain hence a reduced apparent viscosity (Flatt et al., 1992). In a study by Dai et al. (2010), no universal critical exponent was found for the gellan gum in a solution–gel transition since the gelation belonged to the cross-linking of existing macromolecules and the concept of random connectivity failed. The fractal dimension calculated from the viscosity without hydrodynamic interaction nor excluded volume suggested a denser filling structure in the critical gel at higher salt concentration.

In the present study, the content of the gum could not be determined. Therefore, further studies are required in order to identify the different constituents of the gum that could give it such properties.

From these results, this gum seems to have commercial value. The gum from *C. africana* has potential as a product for the cosmetic, pharmaceutical and food industries provided further studies are carried out to identify the phytoconstituents in the gum as well as carrying out toxicity studies. For this reason further studies are underway to determine the chemical composition of the polymer as well as toxicity studies. After these studies, attempts will made to incorporate the gum in natural pharmaceutical, or cosmetic or food formulations.

ACKNOWLEDGEMENTS

The authors wish to express great thanks to the assistant technicians for their technical help and to the respective departments for providing facilities to carry out this study.

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