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Full Length Research Paper

Analysis of a gum from the exudates of *Dichrostachys cinerea* (L.) Wight & Am

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Only little research is currently underway on gums from African plants, yet Africa imports a lot of gums for pharmaceutical and food industries. This study was aimed to investigate the rheological properties, and the moisture and ash contents of the isolated gum resins from *Dichrostachys cinerea.* The gum from this plant exhibited low shear stress even at high concentrations of the gum. The moisture content obtained was 15.8 ± 0.3%, which was rather too high and would only be suitable for formulations that need to remain moisturized. The gum from this plant had little ash content (2.59 ± 0.01%). The gum from *D. cinerea* exhibited low shear stress at high concentrations, while the gum was profoundly affected by the addition of ions. In conclusion, this gum has potential as a product for the cosmetic, pharmaceutical and food industries. Further studies are needed to identify the phytoconstituents in the gum as well as toxicity studies.

Key words: Gum, exudates, *Dichrostachys cinerea,* rheology, moisture.

INTRODUCTION

Nowadays, important imports which serve for African consumer demand are drugs and excipients, which are very high cost goods. These also play a collateral role to raise cost on health service. One solution to this problem would be to search for cheap and locally available substitutes. Gums are some of the excipients that are imported at very high cost. In view of this and other problems, it appears reasonable to search for local alternatives to the imported pharmaceutical gums.

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. Gums are usually formed as part of the cell wall. Many gums are produced by plants after injury. Usually gums are found associated with resins (Gyedu-Akoto et al., 2007). The term resin is applied to more or less amorphous products of complex chemical nature. The materials are complex mixtures of resin acids, resin alcohols, resin phenols, esters and chemically inert compounds known as resins. Resins may be found in irregular masses, which are insoluble in water but soluble in alcohol. Gum resins are usually secreted into secretory

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cavities or ducts. They are normal physiological products but the yield is usually increased by injury.

Acacia gum (Gum Arabic) is used as a general stabilizer in emulsions and as a pharmaceutical necessity in lozenges. The demulcent properties of Gum Arabic are employed in various cough, diarrhoea and throat preparations (Owusu et al., 2005). However, it is incompatible with readily oxidized materials such as phenols and the vitamin A of cod-liver oil. The acacia gum has widespread use in food, drinks and other industries. Other gums such as guar gum and tragacanth are used as suspending agents for insoluble powders in pharmaceutical suspensions. Pectin is an example of gum which is used as a gelling agent. Gums are applied in the production of binding agents in pills and tablets with the example of tragacanth gum (Martins et al., 2009). Some gums such as sterculia (Karaya gum) are used in such countries like the USA and France as bulk laxatives.

Powdered form of some of these gums is used in pastes and denture fixatives powders and has proven particularly useful as adhesives for stoma appliances. In the textile industry, gums are employed as dye carriers. In our search for cheaper and readily available gums from natural sources, *Dichrostachys cinerea* was selected for study.

D. cinerea belongs to the fabaceae genus and is more common at low altitudes where it grows in a wide variety of soils in wooded grasslands. The tree often forms secondary bush on impoverished ground. The bark is dark grey-brown, the stems often twisted and seamed and the branches intertwined giving thick matted appearance. Dwarf lateral shoots are modified to form short compact spines. Leaves are often compound with 4-13 pairs of pinnae, each carrying up to 27 pairs of leaflets. Leaflets are narrowly obovate to lancelote, up to 10 x 3 mm, dark green, rather glossy above but dull below. Glands are conspicuous on the petiole and on the rachis.

Flowers are in auxillary spikes, all floral parts in fives, stamens, pink, sterile staminodes and the other half formed by yellow fertile flowers. The fruits are in the form of a cluster of pods, each up to 10 x 1 cm twisted, contorted and indehiscent. They fall from the tree rot on the ground (Palgrave et al., 1987). It is found in the north, west, central, east and southern regions of Zimbabwe. Traditionally, the roots are chewed and placed on the sites of snake bites and scorpion stings. The leaves, which are believed to produce a local anaesthetic effect, are used as a remedy for sore eyes and tooth ache. *D. cinerea* is also used to treat depressed fontanelle, influenza, cough, scabies, leprosy and oedema. *D. cinerea* plant extracts have been examined and found to possess appreciable antibiotic activity (Gelfand, et al., 1985; Eisa et al., 2000). In this present study, the gum from *D. cinerea* was extracted and subjected to rheological studies, moisture content and ash content evaluation.

MATERIALS AND METHODS

Collection and preparation of the plant material

Some gums ooze out of trees as a result of the natural cracking of the bark. This was the same with *D. cinerea*. Hence, the gum was collected in plastic bags and stored in a cabinet awaiting testing. The plant was collected from Ruwa 30 km east of Harare, Zimbabwe 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 and one at the Herbarium of the Department of Pharmacy at the University of Zimbabwe.

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. At every 10 min 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.

Ash value measurement

Three samples of the gum were taken and placed in pre-weighed crucibles and weighed. These were then placed in a preheated furnace (300°C) for 3 h (charring). 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 desiccator. 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.

Rheological tests

Rheology is the flow properties of materials (Marriott, 1998). Viscosity defined as a fluid's resistance to flow is a very important parameter in the study of flow properties of materials and their suitability in cosmetic, pharmaceutical and food formulations (Harding, 1997).

Change in shear stress with shear rate

Preparation of samples

The samples were prepared by suspending 66 g of the gum in 100 ml of 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 thus; a 33% (w/v) solution was made. The final concentration of the gum was then calculated.

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 viscosity. The lowest shear rate was then selected (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 mentioned earlier, was repeated. Shear rate was increased until the maximum speed was attained at 100 rpm. All the measurements were carried out at room temperature.

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 to 100 rpm. 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 plotted.

Change in shear stress with temperature

2 g gum sample 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 transferred to a refrigerator. Periodic temperature readings were taken. When the solution reached 4°C, it was taken out along with its small water bath for shear stress measurements at 30 rpm. After shear stress measurement, the sample was let to stand on a bench top until the temperature of sample was reached at 10°C. The other temperature studied at 40, 60 and 89°C, respectively, were controlled by the large, automated, temperature controlled unitronic 200 water bath (J.P Selecta). The small water bath was also warmed to maintain the gum solution at the desired temperature, whilst shear stress measurements were been carried out.

Operating conditions

The viscometer's shear rate was kept at 30 rpm for the various temperatures. The temperatures investigated were 4, 10, 25, 40, 60 and 89°C. A graph of shear stress versus temperature was plotted.

Change in shear stress with gum concentration

Procedure

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

Required weight = Concentration x Volume

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

Operating conditions

All the shear stress measurements were carried out at room temperature. The rotational viscometer was operated at 30 rpm for all shear stress determinations. The various concentrations investigated were 0.25, 0.5, 0.75, 1, 2, 2.5, 5, 10, 20 and 33% (w/, respectively.

Change in shear stress with added ion concentration

Procedure

1% (w/v) solution of gum was prepared. The mass of calcium chloride necessary to make 0.1% (w/v) solutions was added to the solutions 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 rpm. The shear stress determinations were carried out at room temperature. More calcium chloride powder was added to make the solutions of higher concentrations. The respective shear stresses of the resulting solutions were measured and recorded.

Operating conditions

1% gum solutions were used for this test. Shear stress measurements were carried out at room temperature and at 30 rpm. The spindle size was R2 throughout. A plot of shear stress versus added ion concentration was plotted.

Statistical analysis

All data was collected into an excel file before transfer to SPSS. All statistical analyses were performed using SPSS for Microsoft Windows version 13.0. Means were analyzed for variance and were separated using Duncan multiple range tests. Any difference was considered significant if the p value was less than 0.05.

RESULTS AND DISCUSSION

In the field, the gum was found in rod shaped tears as well as some rounded tears. The rod shaped tears were up to 0.5 cm in diameter and up to 8 cm in length. The rounded tears exhibited internal cracks that made them opaque. The tears varied in colour from colourless to a pale yellowish red. The dried tears could easily be ground to powder with mortar and pestle and were odorless and tasted bland. A small amount of the powdered form completely dispersed in distilled water to form a clear solution (characteristic of gums). The results are shown in Figures 1 to 4. The moisture and ash content from the gum resin were 15.3 ± 0.4 and 2.19 ± 0.01%, respectively. The results showed that, the change in shear stress with shear rate was non-linear (Figure 1). The change in shear

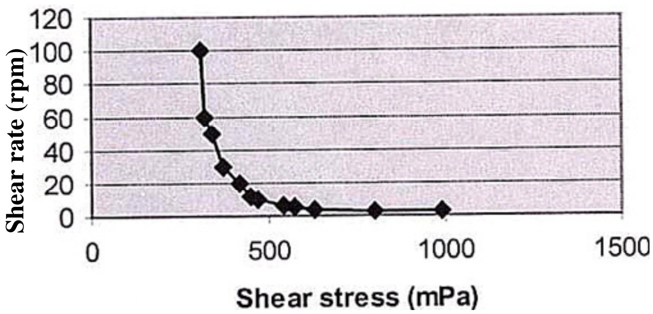

Figure 1. Change in shear stress with shear rate.

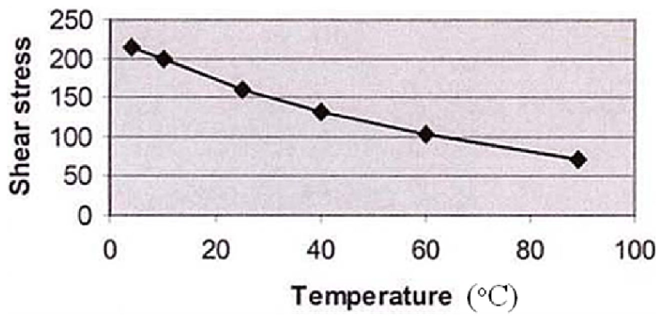

Figure 2. Change in shear stress with temperature.

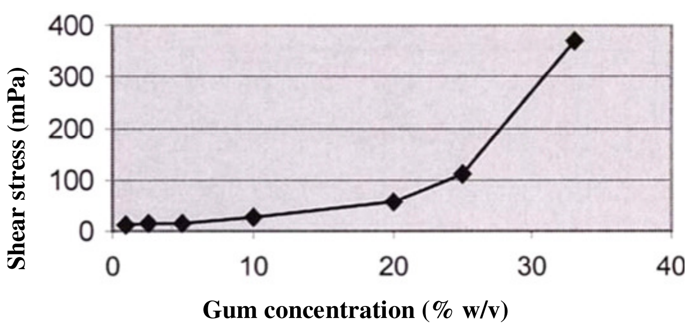

Figure 3. Change in shear stress with concentration of gum.

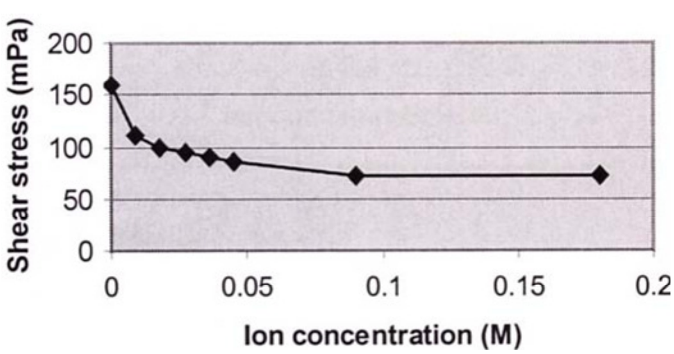

Figure 4. Change in shear stress with concentration of added ion ($CaCl_2$).

stress with temperature was almost linear (Figure 2). The gum from *D. cinerea* exhibited low shear stress at high concentrations of the gum (Figure 3), while the gum was profoundly affected by the addition of ions (Figure 4).

Shear stress is the stress state caused by a pair of opposing forces acting along parallel lines of action through the material. Shear stress plotted against shear rate showed a non linear relationship thus, exhibiting non Newtonian behavior (Figure 1). This behaviour is manifested by pseudoplastic materials (Alakali et al., 2003). These materials display a progressive reduction in viscosity when the rate of shear is increased. Similar behavior was recently described in the study of C*issus populnea* also called 'food gum' (Alakali et al., 2009) and was observed with palm oil (Satimehin et al., 2003).

Pharmaceutical materials that have a non-Newtonian behavior include tragacanth gum. The presence of high molecules in solution results in entanglement with the molecules of immobilized solvent. Under the influence of shear, the molecules become disentangled and align themselves in the direction of flow. This together with the release of the entrapped water molecules accounts for reduced viscosity as observed in the this study.

In a study in Nigeria, Alakali et al. (2009) showed that, at temperatures beyond the boiling point of *Cissus populnea* (70 to 150°C), the apparent viscosity decreased with increasing temperature. Other authors have indicated that, the viscosity decreases with increase in temperature (Ariahu et al., 2001; Alakali et al., 2003). Such behavior 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 (Raina et al., 2006). In fact, rheological data are important in food processing for several purposes such as the design of process equipments 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). In this study, the plot of shear stress versus temperature produced almost a linear graph with a gradient of 0.09 (Figure 2). In fact, the shear stress reduced with temperature. Similar results have been obtained for other studies with substances such as sweeteners and milk type (Telcioglu and Kayacier, 2007).

D. cinerea gum exhibited low shear stress even at high concentration of the gums. Gums that are used as emulsion stabilizers, such as Gum Arabic, behave similarly (Lelon et al., 2010). These materials are made of soluble gum and insoluble resin. The plots of shear stress versus added ion concentration showed that, the gum's shear stresses were reduced by addition of ions (calcium chloride) until a certain minimum value of shear stress was reached. The gum from *D. cinerea* was profoundly affected by the addition of ion and would have little application in formulations that contain salt. In a study by Dlamini et al. (2007), salt concentration did not affect the solubility of Klebsiella oxytoca polysaccharide but decreased viscosity. In that study, the apparent viscosity of the exopolysaccharide decreased at all the salt concentrations, to at least 50% of solutions with no salts. In response to this, it was suggested that this behavior 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 this study, the content of the gum could not be determined. Therefore, further studies are needed in order to identify the different constituents of the gum that could give it such properties.

The moisture content of gums depends on the origin of the material. A recent study by Martins et al. (2009) indicated that, the moisture content of Afzelia Africana gum was low, suggesting its suitability in formulations containing moisture sensitive drugs. In the study, the gum from D. cinerea contained high levels of moisture of 15.8 + or -0.3%. This 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. Therefore, it is important to investigate for the moisture content of potential pharmaceutical material, since its economic importance for industrial application will depend on the optimization of production processes such as drying, packaging and storage (Sonnergaard, 1999; Zaku et al., 2009).

Ash content have immense industrial value as they can be used as tools of quality control, as aids in detection of adulterants of industrial gums and in themselves can serve as crude indicators of mineral ion content. In a study by Gyedu-Akoto et al. (2008), on the physico-chemical properties of cashew gum (CG) collected from four cashew growing districts in Ghana, the ash contents of CG ranged from 0.5 to 1.2% falling within the acceptable level of less than 4% as previously described for gum Arabic (Belitz et al., 2004). In this study, the gum from D. cinerea had little ash content of 2.59 + or -0.01%. Ash content has been reported to be an important property and could be considered as a purity parameter in gums (Glicksman, 1969). The very low values of ash shows that, cashew gum has a good quality of mineral content, the same found in this study with D. cinerea gum. This can be used as a parameter for quality control of the gum described in this study.

In conclusion, this gum had 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 on toxicity. These studies will be carried out in the next generation of studies on this gum.

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