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Research Article

Physicochemical Characterization of *Acacia Sieberiania* Gum

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ABSTRACT

Acacia sieberiana gum obtained from Jigawa forestry, Dutse – Nigeria, was purified and investigated for its physicochemical properties such as particle size distribution, bulk and tapped densities, angle of repose, flow rate, Carr's index, swelling capacity, apparent viscosity, pH effects on viscosity, hydration capacity, moisture content and chromatographic analysis. Using standard and official methods, studies revealed that the gum possessed adequate properties to make it fit for use as an excipient in the formulation of solid, liquid dosages and for modified release formulations.

INTRODUCTION

Acacia sieberiana is an economic tree extensively grown in the Northern Nigeria particularly Yobe Jigawa and Sokoto states. The purified gum is widely used in pharmaceutical, cosmetic, confectionary and paper industries as binders and foaming agents. As polymeric materials, gums such as guar gum have been reported to be suitable in the design of controlled drug delivery systems because of their swelling/ permeability profiles[1]. Pharmaceutical excipients control the physicochemical properties as well as release profiles and availability of drugs from their formulated products[2]. The capability of excipients to provide their intended functions throughout the shelf-life of product unit has to be established; as such information will justify the choice, concentration, mode of incorporation and other characteristics that may influence the final product[3]. Natural polymers are polysaccharides composed of large forms of units with varying chemical compositions, large derivatizable groups and a wide range of molecular weights. These properties impart the needed flexibility which promotes their use as excipients. In addition they are characterized by low toxicity, high stability and biodegradability[4]. An appropriate evaluation of the physical and chemical properties such as solubility, water sorption, swelling capacity, pH effects on viscosity will determine their suitability in the formulation of various drug delivery systems. *Acacia senegal* gum, tragacanth, albizia and guar gums have been used as excipients in pharmaceutical formulations[5].

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MATERIALS AND METHODS

Collection and purification of Gum

The crude *Acacia sieberiana* gum was collected in the semi-solid state from Jigawa state ministry of Agriculture and forestry, packed into a container and protected from direct sunlight.

The method of purifying gums and mucilages designed by Karawya *et al*[6] was adopted. The dried gum was size reduced using porcelain pestle and mortar. One Kilogram (1 Kg) of gum was dissolved in 2 liters of hot distilled water. The hydrocolloid was filtered through 25µm linen. The gum was precipitated from the filtrate by adding 95% ethanol with stirring. The precipitate was washed several times with 95% ethanol until the gum precipitate crumbled. For the 1kg crude gum, 6 liters of 95% ethanol was expended. The wet gum was defatted then dried at 60^0c in the Gallenkamp oven until a constant weight was obtained over 48 hours.

Percentage Yield Determination

The weight of crude gum before purification (*W1*) and after purification and drying (*W2*) was obtained using the metler top loading balance. The percentage yield was calculated using the formula;

W1/W2 x 100 ---------- *1*

Particle size analysis

The dried gum obtained was grinded finely using the pestle and mortar for 30 minutes before particle size analysis by sieving method. Using a nest of sieves arranged in the following order from top to bottom: 1000 µm, 500µm, 250µm, 150µm, 125µm, 90µm and dust collector. The nest of sieves was clamped to an electric sieve shaker, 100 grams of gum powder was placed on the 1000µm sieve while the electrical shaker was operated to sieve the powder in 15 minutes. The fraction retained on each sieve was thereafter recorded.

Determination of Bulk and Tapped Densities

Bulk and tapped densities were determined by modified method[7]. Sixty grams (60 g) of the acacia gum powder was weighed and transferred into a 100ml measuring cylinder the volume (*Vb*) was recorded as bulk volume. The total weight of the powder and cylinder was noted. The bottom of the cylinder was raised 17cms above the slab and made to fall on the platform continuously for 100 taps. The volume (*Vt*) of the powder was recorded and this represents the volume of gum minus the voids and is called the tapped volume.

Bulk density = 60/Vb ----------2

Tapped density = 60/Vt ---------- 3

Angle of repose

Angle of repose was determined as the tangent of the cone formed by powder heap. The height was divided by the radius formed by powder on passing through a funnel orifice to the horizontal[8].

Flow rate

Thirty grams (30g) weight (*w*) of the gum powder was placed in the Erweka flow tester apparatus and allowed to flow through the formed orifice. The time taken (*t*) for all the powder to completely flow out was noted and flow rate was computed from;

w/t ---------- 4

Swelling capacity

The method of Bowen and Vadino[9] was adopted. Five grams (5g) of the gum powder was placed in a 120ml capacity measuring cylinder and tapped 200 times manually. The volume (*Vt*) was recorded and this was followed by the addition of 85ml of distilled water. The volume was made to 100ml and left to stand for 24hrs after which the new volume occupied by gum (*Vv*) was recorded. The swelling capacity (*Φ*) was computed as the ratio of final volume to initial volume.

Φ = Vv/Vt ---------- 5

Hydration capacity

This is also known as water retention capacity. One gram (1g) of gum powder was placed in a centrifuge tube and covered with 10ml of purified distilled water. The tube was manually shaken intermittently over 2hrs period and left to stand for 30mins. This was then centrifuged for 10mins at 3000rpm. The supernatant was decanted and the weight of the gum powder after water uptake and centrifugation was determined (*Xg*)

Hydration capacity *= Xg/1g ---------- 6*

Determination of Apparent Viscosity

One hundred millimeter (100ml) mucilages of gum samples were prepared at concentrations of 10, 20 and 30%w/v. The apparent viscosity of each concentration was determined using Brookfield Synchro-letric viscometer (model RUT). The instrument was operated by immersing the spindle in the mucilage. When set in motion, it is opposed by a viscous drag which is detected and registered as a deflection in the recorder.

The effect of different shear rates of 10, 20, 50 and 100rpm were determined for each of the concentrations used.

Effects of pH on Viscosity of Mucilage

Mucilages of different pH values of 1, 3, 5, 7, 9, 11 and 13 were prepared using 0.1M HCl and 0.1M NaOH. The pH values were determined using Oalkon pH meter (model 1100) at room temperature of 28^0c. These mucilages of different pH values were subjected to varying shear stresses to elucidate any rheological changes.

Chromatographic Analysis

Preparation of sample: To one gram of gum were added 10ml of purified water and 10ml of 7% sulphuric acid and mixture refluxed for 3hrs in a water bath, five milliliters (5ml) of water was subsequently added and extracted with ethyl acetate. Barium Carbonate powder was subsequently added to the supernatant layer containing the sulphate ions and filtered. The filtrate was concentrated on a water bath. The residue was dried over activated silica gel placed in desiccators. This was weighed and used for chromatographic analysis.

Paper chromatographic studies: Seven percent weight per volume (7% W/V) of the hydrolysed sample above and the reference sugar samples **rhammose, xylose, sucrose, arabinose, mannose, ribose and fructose were used.** Using whatman no. 1 chromatographic paper and a capillary tube all the known sugars solutions and that of the sample were spotted on the paper and left to dry. The chromatogram was developed using the descending technique for 30hours.The solvent system used was n-butanol: acetic acid: water in the ratio 4:1:5. After the expiration of the exposure period, the chromatogram was air dried and activated in an oven at a temperature of 40^0c and then sprayed with aniline phthalate solution. The level of each sugar in respect to the references were marked and recorded.

Moisture Content

The moisture content (*MC*) of the purified gum was determined by weighing 100gram of the powder after which it was heated in an oven at a temperature of 105^0c until a constant weight was obtained. The moisture content was then calculated using the following formulae

$$MC = \left(1 - \frac{Wt}{W_0}\right) \times 100 \quad \text{---------- 7}$$

where Wt and W_0 represent the weight of acacia gum after time "t" and the initial weight before heating respectively.

RESULTS

Percentage yield

The weight of purified gum obtained from crude gum was found to be 830grams.

% yield = [830/1000] x 100 = 83%

Particle analysis

Figure 1 depicts the percentage weight of powder retained on each size and the various factors. A high percentage of powder was retained on the 250µm size; therefore mean particle size fraction is 250-500µm.

Physicochemical tests - The results of all these tests are displayed on Table 1.

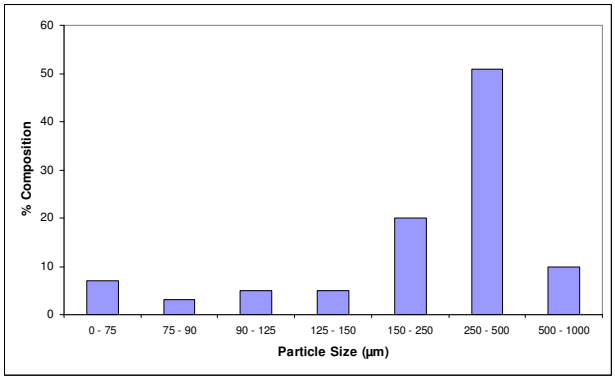

Figure 1: Particle Size Distribution of Gum

Table 1: Physicochemical properties of gum

Parameters	Values
Color	off-white
Odor	odorless
Taste	bland
Moisture content	6.1%
Swelling capacity	2.0
Hydration capacity	1.66
Angle of repose	28.1^0
Hausner's ratio	1.145
Bulk density	0.794
Tapped density	0.909
Carr's index	18%
Flow rate	6.67g/s

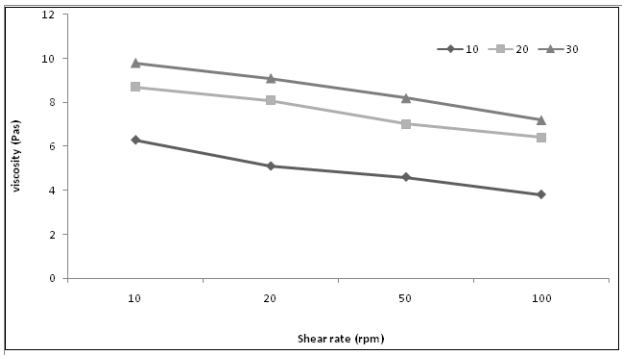

Figure 2: Effect of shear rate on the viscosity of gum at different concentrations

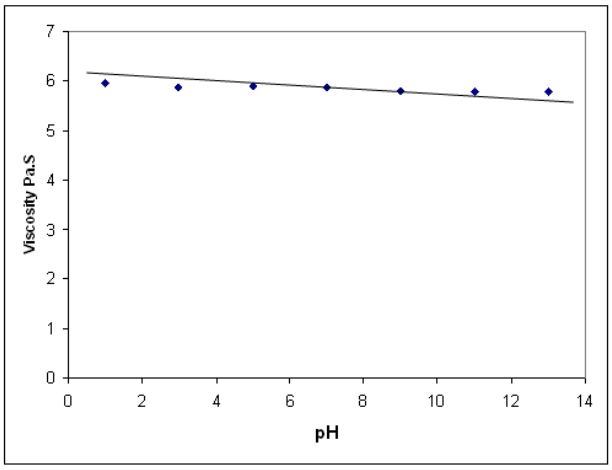

Figure 3: Effect of pH Changes on Viscosity of Gum Chromatographic analysis Result

Identified sugar monomers of *Acacia sieberiana* gum were found to be rhamnose, galactose, arabinose, xylose and fructose.

DISCUSSIONS

The percentage yield of the gum from the crude was found to be 83%. This implies that non-gum constituents and contaminants constitute about 17% of the crude. This yield is high in view of the fact that it was collected as scraps from the dried bark exudates.

The particle size distribution is skewed to the right giving mean particle fraction of 250 - 500 µm. The particle size fraction of 250-500µm constitute about 51% of the bulk powder while 10% were fractions greater than 500µm and 39% was between 75-250µm. The Carr's index of the gum powder was 18% meaning a better chance of volume reduction due to higher compressibility index and it is an indication of better flow for the particles of the gum which were on the high side. The swelling capacity of 2; signifies the hydrophilic nature of gum. This implies that the gum has the capacity to swell into a gelatinous material from which any embedded drug could be released. The rheological investigation of gum reveals a shear thinning, non-Newtonian flow behavior and an increase in viscosity with increased concentration. This property will aid its function as a suspending agent. The hydration capacity of 1.66 shows that the gum retained 60% of its weight of water in less than 3 hrs, therefore water penetration is rapid and could also potentiate the action of disintegrants in tablets. The effect of pH on viscosity of acacia mucilage was found to be insignificant at $p > 0.5$; therefore its use in matrix tablet formulation would not affect the bioavailability of incorporated drug at any region of the gastrointestinal tract. The results of the bulk and tapped densities indicates the volume reduction due to packing under applied tapped pressure, the regular shape, smooth texture, promoted closer packing of particles. The Hausner's ratio and Carr's index previews the degree of densification that would occur during tabletting. As the values of the indices increase the flow of powder decreases[10] giving more likely hood for weight variation. The sugars present were rhamnose, galactose, arabinose, xylose and fructose. A moisture content of 6.1% at $28\ ^0$C is very high and as such moisture sensitive drugs should be packaged in well protected packages to prevent spoilage.

CONCLUSION

The characteristics of the gum have shown that it provides potentials for use as disintegrants and hydrogel in modified release dosage forms. The rheological properties of *Acacia sieberiana* gum also provides a basis for its use as a suspending and emulsifying agent due to the pseudo plastic and thixotropic flow pattern. In view of its high moisture uptake caution should be exercised in utilizing it as an excipient for moisture sensitive drugs and should be stored in airtight containers with handy desiccants.

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