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STUDIES ON SOME PHYSICOCHEMICAL PROPERTIES OF *KHAYA SENEGALENSIS* GUM

*Mahmud, H S., Oyi, A.R and Allagh, T.S

Department of Pharmaceutics and Pharmaceutical Microbiology, Ahmadu Bello University, Zaria

***Author for Correspondence:** mhquinox@Gmail.com

ABSTRACT

Gum exudates from *Khaya senegalensis* (Family Meliaceae) plants grown in northern Nigeria were investigated for its physicochemical properties such as pH, water sorption, swelling capacity and viscosities at different temperatures using standard methods. Khaya gum appeared to be colourless to reddish brown translucent tears. 5 % w/v mucilage has pH of 4.2 at 28 °C. The gum is slightly soluble in water and practically insoluble in ethanol, acetone and chloroform. It swells to about 10 times its original weight in water. Water sorption studies revealed that it absorbs water readily and is easily dehydrated in the presence of desiccants. A 5 %w/v mucilage concentration gave a viscosity value which was unaffected at temperature ranges (28 – 40 °C). At concentrations of 2 and 5 %w/v, the gum exhibited pseudo plastic flow pattern while at 10 %w/v concentration the flow behaviour was thixotropic. The results indicate that the swelling ability of *Khaya senegalensis* gum may provide potentials for its use as a disintegrant in tablet formulation, as a hydro gel in modified release dosage forms and the rheological flow properties may also provide potentials for its use as suspending and emulsifying agents owing to its pseudo plastic and thixotropic flow patterns. In addition, Khaya gum should be stored in air tight containers with desiccators.

Key words: *Khaya senegalensis,* gum, swelling capacity, water sorption, solubility, viscosity.

Introduction

Pharmaceutical excipients are components of dosage forms that enable the formulations to acquire some characteristics which will establish the basic features of the formulated product. These excipients control physicochemical properties as well as the release profiles and availability of the drug in the system (Ram, 2004). The physicochemical properties of a compound are measurable characteristics by which the compound may interact with other systems. The ability of excipients to provide their intended function and perform through out the shelf life of the product must be established such that the information will justify the choice, concentration and characteristics that may influence the final product (EMEA, 2004). One of the commonly used groups of compounds as excipients is natural polymer.

Natural polymers are polysaccharides composed of a large group of polymers with varying chemical composition, large derivitizable groups and a wide range of molecular weights. They are characterized by low toxicity, high stability and biodegradability. These properties make them appealing as pharmaceutical excipients (Anekant *et al*., 2007). Since the ability of these polymers to provide its intended action chiefly lies on its physical and chemical properties, such properties as solubility, water sorption, swelling capacity, pH, effect of temperature, and viscosity among others should be established for any potential excipient.

Acacia, tragacanth, albizia, guar gum are examples of natural polymers that have been used as excipients in pharmaceutical formulations (Martin *et al*., 1991). They are used as binders and disintegrants in tablets and as suspending and flocculating agents.

Khaya gum is a natural polymer, obtained as exudates from *Khaya senegalensis* tree of the Family Meliaceae. Khaya gum has been evaluated as a directly compressible matrix system for controlled release. The findings suggested that the gum could be useful in the formulation of sustained release tablets for up to 5 hrs and may provide a time independent release for longer periods when appropriately combined with HPMC (Oluwatoyin, 2006). It has also been evaluated for use as binder in paracetamol tablets and the findings suggested that, the gum can be developed into a commercial binding agent for particular tablets (Oluwatoyin, 2002).

It is necessary to determine the properties of these gums before been used as excipients in any formulation in order to achieve the goal intended of the formulation. The aim of this work therefore is, to establish some of the physicochemical properties of *Khaya senegalensis* gum grown abundantly in Zaria, Nigeria as an excipient in pharmaceutical formulations.

MATERIALS AND METHOD

Collection and Treatment of Gum

Khaya senegalensis gum was obtained from the trunk of khaya trees grown around samaru, Zaria town of Kaduna state, Nigeria. The gum was collected around mid-November during the day time. The plant material had earlier been identified and authenticated and assigned a voucher number 872 in the herbarium Department of Biological Sciences of Ahmadu Bello University Zaria. For the processing of the gum, the method of Femi-Oyewo *et al*, 2004 was adopted with some modifications. The gum was dried in an oven (BS Size 3, Gallenkamp) at 40°C for 2 hrs and size reduced using a blender (Model. MJ-176 NR, Matsushita Electric Industrial Co., Ltd. Osaka, Japan). It was hydrated in double strength chloroform (May &Baker reagent, Dagenham, England) water for 5 days with intermittent stirring to ensure complete dissolution and then, strained through a 75µm sieve to obtain particulate free slurry which was allowed to sediment. Thereafter, the gum was precipitated from the slurry using absolute ethanol (Sigma-Aldrich, Germany), filtered and defatted with di- ethyl ether (Sigma- Aldrich, Germany). The precipitate was dried in the oven at 40°C for 48 hours. The dried flakes were pulverized using a blender and stored in an air tight container.

Physicochemical tests

In order to characterize the gum, it was subjected to the following physicochemical tests:

Determination of Solubilities in various solvents

The solubility of Khaya gum was determined in cold and hot distilled water, acetone, chloroform and ethanol. 10mg sample of each gum was added to 10ml of each of the above mentioned solvents and left overnight. 5ml of the clear supernatants were taken in small pre-weighed evaporating dishes and heated to dryness over a digital thermostatic water bath (Model. HHS, McDonald Scientific International). The weights of the dried residue with reference to the volume of the solutions were determined using a digital top loading balance (Model. XP-300, Denver instrument, USA) and expressed as the percentage solubilities of the gums in the solvents (Carter, 2005).

Moisture sorption studies

The method described by Josiah (1991) was adopted. A dried evaporating dish was weighed and 2g of Khaya gum powder was weighed into it. The final weight of the dish was noted and then placed over water in desiccators for a period of 5 days, thereafter removed and transferred into other desiccators over activated silica gel (desiccant) for another 5 days. The dish with its contents was weighed on daily basis and its water content calculated.

Swelling properties

The method of Bowen and Vadino (1984) was adopted. A 5g quantity of the gum powder was placed in a 200ml measuring cylinder and tapped 200 times. The volume (Vi) of the gum in the cylinder was recorded. Water was added to the mass to reach the 100ml mark, in the cylinder and left to stand for 24 hours. The new volume of the gum in the cylinder was then recorded as Vii.

The swelling capacity (Φ) was calculated as the ratio of the final volume (Vii) to the initial volume (V1)

$$\Phi = Vii/Vi \quad \text{......equation 1.0}$$

The procedure was repeated to obtain duplicate values.

Determination of Apparent Viscosity of the Mucilage

A digital Brookfield viscometer (Model DV- I PRIME) was used for this study. It measures the torque required to rotate an immersed spindle in a fluid. The instrument features a rotating spindle with multiple speed transmission and interchangeable spindles that measure a variety of viscosity ranges. Different concentrations (2.0, 5.0 and 10%w/v) of the gum mucilage samples were prepared in a 600ml beaker, appropriate enough to immerse the spindle groove in the fluid. Speed of rotation was varied (10, 20, 50, and 100 r.p.m) to determine its effect on the viscosity values since drag force is known to alter with changes on the spindle size and rotational speed. For each concentration and at each rotational speed triplicate measurements were made.

Determination of the pH of Gum Mucilage

The pH of the gum mucilage (5%w/v concentration) was determined using an Oaklon pH meter (Model 1100). The pH meter was set to neutral (7.4) at a room temperature of 28 °C and the electrode was immersed into the mucilage. The reading on the meter recorded. Triplicate measurements were made.

Effect of storage time on viscosity

Different concentrations (2.0, 5.0 and 10 %w/v) of khaya gum mucilage were prepared and their viscosities at a range of storage temperatures (28 – 40 °C) were determined over a period of 21 days, using a Brookfield viscometer as described above.

RESULTS AND DISCUSSION

Gums are polysaccharides with numerous sugar molecules and, therefore partially dissolve in water. The observed sparing solubility of khaya gum in water may be due to the linear nature of the polymer, which has been reported to be less soluble compared to the branched components (Lima *et al*, 2002). Aslam *et al*., 2006 reported that *Khaya grandifolia* has only limited solubility in water but dissolves in sodium carbonate with removal of calcium ions. Khaya gum slight solubility in water most likely is peculiar to other members of the *Meliaceaceae* gum producers.

Table 1: Basic physico-chemical properties of *Khaya senegalensis* gum

Parameters	Description (values)
Colour	Colourless to reddish brown
pH of mucilage (28°C)	4.2
Swelling capacity	10
Viscosity (m.pas) at 50rpm	**Values**
2.0%w/v	6.20
5.0%w/v	22.40
10.0%w/v	390.0
Solubility (%w/w)	**Values**
Hot water	9.20
Cold water	9.40
Acetone	0.00
Chloroform	0.00
Ethanol	0.02

Solubility values presented in Table 1.0 showed that khaya gum is insoluble in the three organic solvents (acetone, chloroform and ethanol) but slightly soluble in water (hot and cold). As depicted also in Table 1.0, the gum had a swelling capacity of 10.0, indicating that the gum contains linear polymers. Gennero *et al.,* (2000) reported that swelling of a linear polymer without dissolution is an indication that it is cross-linked. The cross-links tie the macromolecular chains together by primary covalent bonds thereby transforming each particle into a single giant molecule. The swelling ability of polymers enables it to absorb water and reduce the fluidity of diarrhoeal stool one of the major uses of gums. Cross-linked polymers are also suitable for use as disintegrants because they form hydro gels, they can be used for controlled release dosage forms. The gum from *Khaya grandifolia* have been explored as coatings for drugs targeting the colon (Oluwatoyin *et al*., 2005) and also investigated as tablet matrices (Oluwatoyin *et al*., 2006) for modified release dosage form. The water sorption result presented in Fig.1.0 can be showed that khaya gum absorbs substantial amount of water when stored in high humidity environment. The amount of water sorption increased steadily to a saturation point in 5 days. In the presence of desiccant, the absorbed water molecules are rapidly lost within a few hours. Similar trend was observed with cashew gum (Abdulsamad, 2004). The implication of this is that khaya gum, when stored in damp environment can easily be susceptible to microbial and physicochemical deterioration as a result of high moisture content. Furthermore, the integrity of the gum can be maintained when stored in air-tight containers and in the presence of desiccants. The effects of concentration, temperature, storage time and speed of rotation on viscosity of Khaya gum mucilage are shown in Figures 3, 4, 5 and 6 respectively.

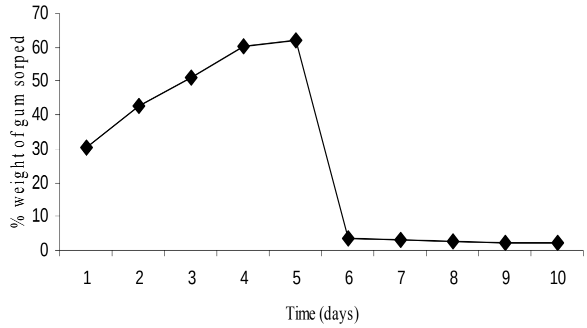

Fig.1.0: Percentage sorption capacities of *Khaya senegalensis* gum powder stored at 90%RH and desiccant environment at different storage times

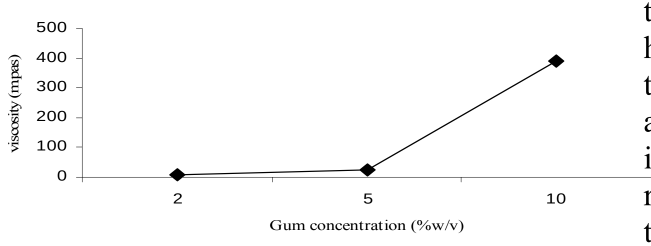

Fig.2.0: Viscosities (m.pas) of different concentrations of Khaya gum mucilage

The viscosity of Khaya gum is found to be dependent on concentration at the same shear rate. It increases with increase in gum concentration. The variation in cohesiveness of the mucilage is apparent as viscosity of the gum was more at 10%w/v compared with values at 2 and 5%w/v concentrations. Generally, molecules in a fluid have different shapes and sizes. The force required to move these molecules in the fluid is determined by their type of bond, shape and size. The flow properties of highly concentrated slurries with insufficient liquid to completely fill the voids between the particles results in a three phase mixture; solid, liquid and air. The presence of air makes the material compressible, and therefore the more the slurry is compressed, the greater the viscosity (Brookfield Eng. Labs Inc.Lab. Manual, 2007). This probably explains why khaya mucilage has a higher viscosity value which is more viscous at a concentration of 10 %w/v compared with 2 and 5 %w/v mucilage concentrations. Though, most fluid's viscosities decrease as temperature increases, change in temperature had no significant effect on the viscosity of the gum mucilage. Result of viscosity values at different storage times showed an initial increase, followed later by a decrease. The rise and fall in viscosity could be attributed to the nature of the gum as it hydrates over time. Hydration was more pronounced with 2%w/v khaya gum mucilage concentration compared with 5%w/v concentration. This could be due to the presence of excess liquid for absorption by the gum particles. It showed that maximum hydration is achieved in 14 days after which no more water can be incorporated into the voids created by the linear cross-linked polymers.

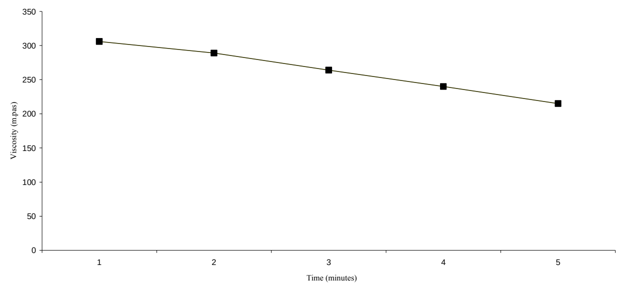

Fig.5.0: Viscosity values of Khaya mucilage (10%w/v) at various Shearing Times.

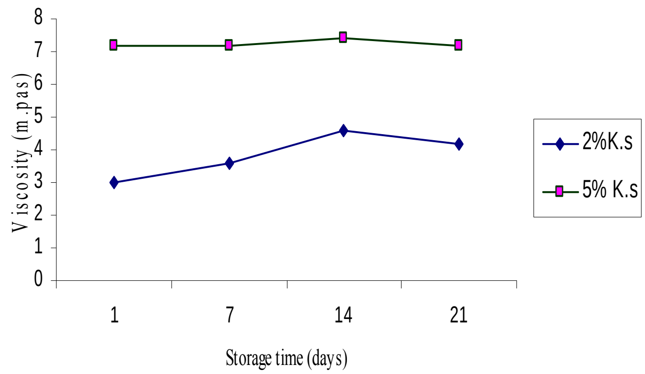

Fig.3.0: Viscosities of different concentrations of Khaya gum mucilage at various storage times

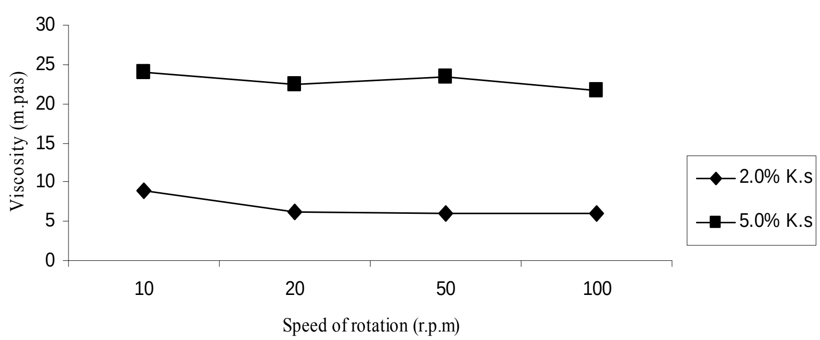

Fig.4.0: Viscosities of different concentration of Khaya gum mucilage at various speed of rotation

Khaya gum at concentrations of 2 and 5%w/v exhibited pseudo plastic flow pattern using a spindle no. 62 and a guard leg. However, the 10% w/v concentration could not be sheared with the same spindle size because it was out of range, but at 50 r.p.m the flow pattern was observed to be thixotropic. These flow patterns are of immense importance in liquid formulations such as suspensions owing to their ability to keep the preparation suspended. Ram (2004) reported that, for an ideal suspension, it is best to have high viscosity during storage (preventing sedimentation) and low viscosity when sheared to ease administration. This is achieved by the use of pseudo plastic as well as thixotropic suspending agents which can maintain the suspensions in flocculated form.

CONCLUSION

The results obtained indicated that on physical examination Khaya gum occurs as colourless to reddish brown, translucent tears. The gum mucilage is acidic with a pH of 4.2 at 28°C. It is slightly soluble in water and practically insoluble in semi-polar solvents like ethanol, acetone and chloroform. It swells to about 10 times it original weight in water. Water sorption studies revealed that it absorbs water readily and can easily be dehydrated in the presence of desiccants. The viscosity of the gum was found to increase as the gum concentration increased and, at concentrations of 2 and 5%w/v, khaya gum was observed to exhibit pseudo plastic flow pattern while at 10%w/v concentration the flow behaviour was thixotropic when sheared at 50 r.p.m. In conclusion, the swelling ability of *Khaya senegalensis* gum may provide potentials for its use as a disintegrant in tablet formulation, as a hydro gel in modified release dosage forms and as a suspending agent and emulsifying agent owing to its pseudo plastic and thixotropic properties. In addition the gum should be stored n air tight containers with desiccators.

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