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Original Research Article

Physicochemical evaluation of *chrysophyllum abidum (sapotacae) gum extract* and its tableting characteristics in comparison with acacia *Senegal gum*

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Abstract

Purpose: A comparative study was carried out to investigate the physicochemical and tableting characteristics of the gum extract from *Chrysophyllum abidum* and *Accacia Senegal* on paracetamol granules.
Methods: Chrysophyllum abidum gum was precipitated with methanol and the physicochemical properties (swelling index, particle density, and solubility in various solvents) were evaluated and compared with acacia gum as standard. Varying concentrations (0 – 7.5%w/v) of either C*hrysophyllum abidum* or A*cacia senegal* mucilages were used to wet 15 g each of paracetamol powder as a poorly compressible drug model to form granules. Resulting granules were compressed to tablets (500±9.5 mg) at a constant load of 35 arbitrary units on the scale. The tablets were equilibrated over night for 24 hours before their evaluations. Tablet properties assessed included packing fraction, friability, and tensile strength.
Results: *C.albidum* gum displayed similar physicochemical properties in colouration and solubility in both aqueous and organic solvents as well. Both gums were soluble in aqueous solvent only. The viscosities of mucilages from the gums showed that C. albidum was five times more viscous than *A. Senegal,* and viscosity was concentration dependent. *C. albidum* formed compacts which were comparable with A. Senegal at the arbitrary load employed. The packing fraction of *C.abidum* was in the range of 0.71 – 0.8 while A. *senegal* ranged from 0.85 – 0.87. This showed that *A. Senegal* formed more consolidated tablets with closer packing of the granules than *C. albidum.* Tablet formed from *C. albidum* were more friable with values ranging from (1.0 - 2.7%) than those from *A.senegal* (0.7 – 1.5%). Tensile strength values ranged from 0.37 – 0.71 MNm^{-2} (*C .albidum)* and 0.46 – 0.81MNm^{-2} for (*A. Senega)* respectively.
Conclusion: The results from the study showed that the physicochemical and tableting characteristics of *C.albidum* compared favourably with A. Senegal. The novel gum extracted from C.albidum could therefore serve as a substitute binder in tablet formulations.
Keywords: Chrysophyllum abidum, accacia senegal, binder properties, paracetamol tablet, tensile strength,packing fraction, viscosity.

Indexing: Index Copernicus, African Index Medicus

Introduction

A pharmaceutical dosage form consists of the active pharmaceutical ingredient in additionto other inert substances which may be included in the formulation to assist the manufacturing and/or to optimize the overall performance of the final dosage forms. Such inert substances are usually referred to as excipients, they are safe; fulfills specific functions directly or indirectly, influencing the rate and extent of release and /or absorption of the active ingredients. The degree or extent of optimal performance of pharmaceutical excipients is usually assessed from a consideration of its physicochemical properties exhibited by the excipient alone or in conjunction with active pharmaceutical ingredient. For instance, the tableting properties of various binders have been characterized from the evaluation of its compression properties of the material under investigation [1, 2, 3, 4], while similar emulsification and suspension

properties of gums have equally been assessed from such physicochemical evaluations [5, 6]

A large number of materials obtained from plants are readily available and have been explored extensively as pharmaceutical excipients in drug formulations [3, 5, 6]. Gums as pathological exudates following an injury to woody or non-woody plant parts such as bark, seeds, sap, roots, rhizomes, fruits and leaves or unfavourable conditions have been investigated extensively as binders, suspending agents or as emulsifying agents respectively [7, 8]. Natural gums are economic, readily available and environmentally friendly. In recent times, there has been increasing attention on the pharmaceutical application of gums as excipients in various dosage formulations. Over the years, there has been over dependence on importation of raw materials in the pharmaceutical industries in Nigeria, and this has posed a strong challenge on both foreign reserve and exorbitant cost of drug production in our country. Again, the final pharmaceutical product is unaffordable to the common man on the long run.

Chrysophyllum abidum (*sapotaceae)* popularly known as African white star apple is primarily a forest tree species and it is widely distributed across Africa. It is found in North East Tropical Africa e.g. Sudan, East Tropical Africa e.g. Kenya, West Africa e.g. Nigeria. In South Western Nigeria the fruit is called Agbalumo, and popularly referred to as Udara in South Eastern Nigeria. The fruit has in recent times become a crop of commercial value in Nigeria and the fleshy pulp is eaten as snack by young and old. However, literature search showed that there is no previous investigation on the extraction and characterization of its gum extract. Hence, the objective of this study therefore was to isolate gum from *chrysophyllum abidum* fruit pulp and to explore its potentials as a binder in tablet formulation in comparison with a standard gum *Acacia Senegal*.

Experimental

Fresh fruits of *Chrysophyllum abidum* were purchased from a local market in Ugbojobo, a suburb village via Benin City, Edo State, Nigeria. The fruits were light brown in colour, sub-spherical in shape, and measuring 3-5 cm in diameter. Paracetamol powder (Halewood Chemicals Limited, England), a poorly compressible material was used as a drug model. Maize starch (BDH, England) was employed in the study as a disintegrant. Novel gum extracted was investigated as a binder in the formulation of paracetamol tablet in comparison with *acacia Senegal (leguminosae)* as a standard gum.

Extraction of the gum

Fresh fruits were washed with clean water. The seeds were removed and the pulps of the fruits were extracted with a knife. A small pore size nylon cloth was used to manually strain the juice out of the pulp. A 1200ml juice obtained was treated with equal volume of methanol (i.e. ratio1:1) to precipitate the gum. The precipitate obtained was washed with distilled water, strained with a muslin bag into a cake which was air dried for two (2) days. Resulting dried mass was reduced to a fine powder of size range 350 - 500µm. Powdered mass obtained was stored in an air-tight chamber with activated silica gel for 24hrs before characterization.

Physicochemical characterization of the gums

Determination of solubility profile in various solvents

The solubility of *C.albidum* gum was determined in various solvents at varying temperatures cold (15 - 20±5^{o}C) and hot (80 - 90±5^{o}C) as follows: distilled water, 0.1N HCl, 0.1N NaOH, acetone, chloroform, methanol and ethanol at room temperature. A sample (0.50 g) of the gums either of *C. albidum or A. Senegal* was dispersed in 50 ml each of the various solvents. Resulting dispersions were observed for homogenous dispersions as a sign of possible dissolution.

Determination of viscosity profile of mucilages

Varying concentrations of the gums (*C. albidum or A. Senegal*) were made in hot water (1-7%w/v). Viscosities of the resulting mucilage of varying concentrations of the gums were determined at room temperature (28±2^{0}C) according to the British.Pharmacopoeiea 2012 using a suspended level viscometer. The viscosity, η, relates directly to the time (s) taken for a specified volume of the sample fluid to flow through the capillary of the viscometer as shown in the equation (i) below, [9]. Triplicate determinations were made and mean ± SD was reported.

$$V/t = \frac{\pi P r^4}{8\eta L} \quad \text{..... (1)}$$

V is the volume of liquid flowing through the capillary in time t and P is the pressure difference across the capillary, since the test was of comparative value, the time of flow (s) was taken as the index of viscosity.

Determination of bulk and tapped densities of the gums

Bulk and tapped densities were determined by modified method, [10] as follows. A sample (2 g) of the gums either of C.albidum or A.senegal was transferred into 100 ml measuring cylinder and the volume (Vb) was recorded as bulk volume. The cylinder was then subjected to 100 taps using the Erweka tap density apparatus (model TA, Germany) as described previously [11] and the tapped volume

(Vt) was noted. The procedures were replicated three times and mean values were reported. The bulk and tapped densities were computed respectively using equations (2 and 3) below respectively.

$$\text{Bulk density} = \frac{\text{weight of granules (g)}}{\text{Poured (bulk) volume (cm}^3\text{)}} \quad \ldots\ldots (2)$$

$$\text{Tapped density} = \frac{\text{Weight of granules (g)}}{\text{Tapped volume (cm}^3\text{)}} \quad \ldots\ldots (3)$$

Determination of swelling index

A sample (2 g) each of the powdered gums was filled into a 100 ml measuring cylinder and tapped to despair off the air or voids and the volume was noted as (Vt). Distilled water (40 ml) was added and left to stand for 24 hours over night and the volume occupied (Vv) by the gum sediment was noted. The swelling index (θ) was computed as the ratio of final volume to the initial volume, [12].

Determination of specific densities

The fluid displacement method as previously adopted by other workers was employed, [13]. A pycnometer was filled with liquid paraffin, covered and weighed. A sample (0.5 g) of each of the gums was filled into the empty pycnometer and the weight was noted. The pycnometer with the gum was filled with liquid paraffin and the stopper replaced, the excess liquid was wiped off and the final weight was noted. Replicate determinations were carried out and the mean values were employed to compute the density of the gum as show in equation (4) below:

$$\mathbf{Pg} = \frac{W}{[(a+w)-b]SG} \quad \ldots\ldots (4)$$

W is gum particle weight, SG is specific gravity of liquid paraffin, a is the weight of pycnometer + liquid paraffin and b is weight of pycnometer + liquid paraffin + gum.

Preparation of paracetamol granules

Varying concentrations of the gum mucilage (1-7.5% w/v) were used to granulate 15 g of paracetamol and 1.5g of lactose powder. The wet mass was passed through a laboratory sieve of aperture size 1.7 mm and dried at 60^{o}C for 1 hour in a hot air oven. It was in turn passed through another sieve of lower dimension (710µm) and dried finally at 60 for 5 hours and stored over night in an air tight dessicator activated with dry silica gel before their characterization.

Preparation of the tablets

Resulting granules formed from *C. albidum* or *A. senega* gum were compressed into tablets of mean weight 500±7.32 mg, thickness 3.28±0.54 mm and diameter 12.02 mm using the single punch tableting machine (Manesty Machines, Type F3, Uk) at an arbitrary load of 35 arbitrary units. The die and punch surfaces were lubricated with 1%w/v dispersion of magnesium stearate in alcohol to prevent sticking of granules to the surfaces.

Evaluation of tablets

The degree of consolidation of a tablet is measured from the determination of its packing fraction as given by the equation (5) below, [3]:

$$Pf = \frac{W}{\pi r^2 t \rho} \quad \ldots\ldots (5)$$

where W is the mean weight of tablets (mg), r is the radius (m) and t is the thickness (m) and ρ is the particle density of the gum used in the tablet formulation and it was obtained from fluid displacement technique as described previously,[14].

Tensile strength of tablets is a measure of the stress needed to cause diametral fracture of the tablet and this was computed from mean values obtained from the hardness test on the tablets (n = 10) using a similar technique previously adopted [15] and the computation was carried out using equation (v) below; [16].

$$T = {}^{2P}/_{\pi Dt} \quad \ldots\ldots (6)$$

where P is the applied load that brings about the diametral fracture of the diameter, d, and t is the tablet thickness (m).

Results

Physicochemical properties of the gums

The results of the physicochemical properties of the gums are presented in Table 1. The organoleptic properties of the gums *(C.albidum)* revealed coarse texture, light brown colour with a pleasant fruity odour and these features compared favourably with the standard A. Senegal, with similar light brown colour and a smooth texture.

Table 1: Physical properties of the gums of *C. Albidum* and *A. Senegal*

Parameter Evaluated	*C. Albidum*	*A. Senegal*
Bulk density (g/ml)	*0.7*± 0.02	*0.83*± 0.04
Tapped density (g/ml)	*0.8*± 0.01	*0.89*± 0.02
Hausner's ratio	*1.31* ±0.23	*1.05* ± 0.13
Carr's index (%)	*11.25*± 0.15	*24.24* ±0.23
True density (g/ml)	*2.01* ±0.14	*1.05* ± 0.02
Swelling capacity	*2.0* ± 0.4	*2.4* ± 0.3

Effect of gum type and concentration on the viscosities of the mucilage

The results of the viscosity index of the gum mucilages are shown in Figure 1. Generally, an

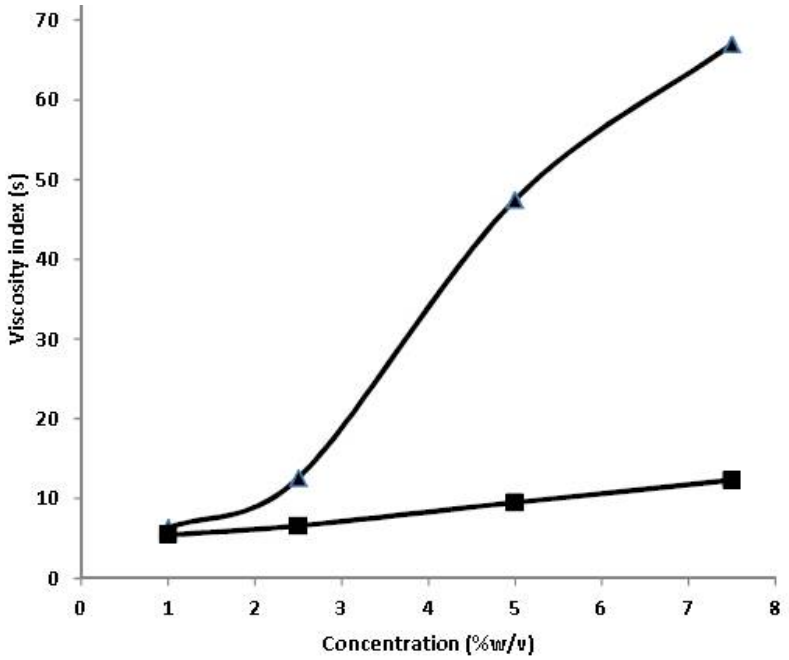

Figure 1: Variation in concentration of gum with viscosity index of the mucilages: C. albidum (▲) and A Senegal (■)

Table 2: Influence of concentration of binder on the consolidation properties of the tablets

Gum mucilage conc. (%w/v)	*C. albidum*				*A. senegal*			
	Carr's Index (%)	Hausner Ratio (HR)	Tensile strength ($TMNm^{-2}$)	Packing fraction (P_f)	Carr's Index (CI, %)	Hausner Ratio (HR)	Tensile strength ($TMNm^{-2}$)	Packing fraction (P_f)
1	26.9±0.5	1.4±0.02	0.37	0.71	12.00±.8	1.13±0.5	0.46	0.86
2.5	21.4±0.7	1.27±0.01	0.56	0.72	25.9±5	1.35±0	0.62	0.86
5	14.7±0.3	1.15±0.05	0.63	0.72	28.6±.6	1.4±0.0	0.72	0.85
7.5	21.2±.7	1.27±0.08	0.71	0.80	15.6±8	1.2±0.0	0.82	0.87

increase in mucilage concentration brought about a corresponding increase in viscosity of the gums. The results showed that *C. albidum* was much more viscous than A. Senegal; this increase was more markedly pronounced especially at higher concentrations. For instance, at a concentration of 7.5% w/v gum mucilage, the viscosity of *C. albidum* was five times that of *A. senegal*.

Effect of concentration of gum mucilage on the flow properties of granules and consolidation of the tablets

The results of the effect of binder concentration on the compression properties of as reflected by Carr's index (CI) and Hausner ratio (HR) of the granules are shown in Table 2. The compressibility index (CI) of the granules ranged from 14.7±0.3 to 260.5% for *C. albidum* and 12.0±0.8 to 28.6±0.6% for *A senegal*, while Hausner ratio values ranged from 1.15±0.05 to 1.4±0.02 for *C.albidum* and 1.13±0.5 to 1.4.0±.0.0 for A.senegal. The tensile strength values ranged from 0.37 -0.71 *(C. albidum)* and 0.46 – 0.82 *(A. senegal)*.

Discussion

Both gums were generally soluble in water and insoluble in acids, bases or organic solvents even at elevated temperatures. Both gums are highly hydrophilic in nature as revealed by the similar swelling capacity of 2.0± 0.4 and 4.4± 0.3 for *C. Albidum* and *A. Senegal* respectively. The bulk and tapped densities indicated that there was marked reduction in the volumes of the powders when subjected to tapping pressure. This is used as measure for assessing the compaction properties of powders. A previous report has been given on the application of this technique in the evaluation of the compaction properties of *Delonix regia* gum, [17]. The results of compressibility index (CI; %) are shown in Table 1. *C.albidum* had a value of *11.25*± 0.15 while *A. Senegal* displayed higher value *24.24* ±0.23 respectively. This is suggestive of excellent flow of the granules made from *C. Albidum* while A. senegal displayed poor flow characteristics; flow properties of powders have been known to influence the consolidation behaviour, [18]. Both gums were generally soluble in water and insoluble in acids, bases or organic solvents even at elevated temperatures. Both gums are highly hydrophilic in nature as revealed by the similar swelling capacity of 2.0± 0.4 and 4.4± 0.3 for *C. Albidum* and *A. Senegal* respectively. The bulk and tapped densities indicated that there was marked reduction in the volumes of the powders when subjected to tapping pressure. This is

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The higher viscosities of the gum mucilage of *C. albidum* may be attributed to strong and extensive polymer structural arrangement within the molecule, and this has been reported previously to account for the overall polymer-polymer cohesion in applied films, [3,19,20]. The more viscous a polymer solution is the stronger the interconnective structure and the more the cohesive properties expected and hence their intrinsic properties. Values of differences in viscosity of starches had been employed earlier in determining the binder effectiveness of some starch mucilages [2]

Preliminary investigations showed that granules irrespective of gum type exhibited satisfactory flow properties with angle of repose ranging from 15.32 to 30.36^{O} except at low concentration of 1%w/v of *C. albidum* which did not flow at all, and this may be attributed to insufficient binder content in the granules. All granules exhibited satisfactory compression properties at all binder concentrations. Compressibility index and Hausner's ratio of a powder bed are measures of degree of packing of the granules. An increase in the binder concentration resulted in a corresponding slight increase in tensile strength. This effect was more marked with *A. senegal* than *C. albidum.* It was observed that the packing fraction (P_f) of tablets made with both gums as binders were similar and closely related to each, with little or no variation. The P_f values ranged from 0.71 to 0.8 *(C.albidum)* and 0.86 – 0.87 *(A. senegal)* respectively. Previous studies had reported a positive correlation between tensile strength and packing fraction, [21]. The packing fraction is a tool used for measuring the degree of consolidation of particles in tablets.

Conclusion

The results from the study showed that the physicochemical and tableting characteristics of *C. albidum* compared favourably with *A. senegal*. The novel gum extracted from *C. albidum* could therefore serve as a substitute binder in tablet formulations.

Declarations

The authors acknowledge the technical support received from the departmental laboratory staff.

Conflict of Interest

No conflict of interest associated with this work.

Contribution of Authors

The authors declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by them. FEE conceived and designed the study and prepared the manuscript, COE supervised collection and analysis of data, while FII and AEA carried out all laboratory investigations. All authors read and approved the manuscript for publication.

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