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Full Length Research Paper

Evaluation of the binder effects of the gum mucilages of *Cissus populnea* and *Acassia senegal* on the mechanical properties of paracetamol tablets

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A comparative study has been carried out to investigate the binder effects of the gums of *Cissus populnea* and *Accasia senegal* on the mechanical properties of paracetamol tablets. Tablet mechanical properties evaluated include the packing fraction (P_f), the tensile strength (T) and the brittle fracture tendency (BFI). Varying concentrations of the gum mucilage ranging from 1 - 15% (w/v) was prepared and their relative viscosities determined. Each concentration was used to wet massed paracetamol powder to form granules. Tablets of paracetamol (500 ± 6.5 mg) were compressed at a constant compression load (7 arbitruary units on the scale). The tablets were equilibrated for 24 h before evaluation. At all binder concentrations *A. senegal* gum produced harder and more consolidated tablets than *C. populnea* as reflected by the higher T and P_f values respectively. For instance, the T and P_f values of the tablets at binder concentration of 10% (w/v) were 0.69 MNm^{-2} and 0.47 (*A. senegal*) and 0.57 MNm^{-2} and 0.23 (*C. populnea*), respectively. On the contrary, an increase in binder concentration generally resulted in a decrease in BFI values and this decrease was more marked with *C. populnea*. The study showed that *A. senegal* mucilage displayed better tableting characteristics and higher tendency for ameliorating capping tendency. Both mucilages have the potentials for substitution as binder for the more expensive starches in tablet formulation.

Key words: *Cissus populnea*, *Acassia senegal* gum, paracetamol tablet, tensile strength, brittle fracture index, packing fraction, binder effect.

INTRODUCTION

Binders are pharmaceutical excipient that are commonly employed in tablet formulation to impact cohesion on the powder mix and hence improves on the flow properties on the granules (Kottke et al., 1992; DiSanto, 1995; Prescott and Barnum, 2000). Binders act by causing aggregation of powders thereby forming granules through the process of granulation. They modify the cohesive properties of the granules by promoting the formation of strong cohesive bonds between such particles.

The tablet characteristics of any pharmaceutical materials can be obtained from studies on its mechanical properties and such properties have been studied through various techniques based on their plastic and elastic behaviour during compression and/or decompression cycles (Krycer et al., 1982a; Okor, 1996; Itiola and Pipel, 1986). The brittle fracture tendency phenomenon (BFI) which is a measure of the tendency of the compact to cap or laminate during ejection from machine dies has also been employed as one of such techniques, (Hiestand et al., 1977; Okor et al., 1998; Uhumwangho et al., 2004, 2006). Its value is computed from the expression below:

$$BFI = 0.5(T/T_0 - 1) \quad (1)$$

T_0 and T are the tensile strengths of tablets with and without a centre through hole respectively.

In recent times, increasing attention has been given to the application of gums of various sources as pharmaceutical excipeints. Gums generally are polysaccharides which are polymeric in nature of natural substances obtained from woody and non-woody plant parts such as bark, seeds, sap, roots, rhizomes, fruits, and leaves. Hence, in this study we have investigated the binder effects of *Cissus populnea* and *Acassia senegal* gum mu-

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cilage on the mechanical properties of paracetamol tablets. The influence of viscosity of the gums on the brittle fracture tendency of paracetamol tablets was also evaluated.

MATERIALS AND METHODS

Materials

Paracetamol BP (Halewood Chemicals Limited, England) was used as a model because it has poor compression properties. Maize starch (BDH, England) was employed as a disintegrant. *C. populnea* (family: Amplidaceae) is a plant that is widely grown and widely distributed in the Savanna forest of Benue State, Nigeria. The gum is a polysaccharide polymer obtained from the stem bark of the plant. The gum was extracted using the binary mixture methods of Ibrahim and Dawes (2000), while *A. senegal* (family: *leguminosae*) also a polysaccharide gum powder of plant origin (pharmaceutical grade) were investigated as binders in the formulation of paracetamol tablet.

Preparation of the gum mucilage

Varying concentrations ranging from 0 - 15% (w/v) of the gums either *C. populnea* or *A. senegal* were dissolve in distilled water and allowed to stand for 3 h for complete dissolution of the gums at room temperature (30°C) to form the mucilage.

Determination of viscosities of the gums

The viscosities of the mucilages were determined with a U-tube (Ostwald) viscometer (Gallenkamp Griffen Technical, model B/SU, size A) at room temperature (30°C). The viscosity, n, relates directly to the time (s) taken for a sample volume of the fluid to flow through the capillary of the viscometer, which is shown in equation. (2) (Richards, 1972):

$$V/t = \frac{\pi P r^4}{8n\lambda} \quad (2)$$

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

Preparation of the granules

200g of the paracetamol powder was wet massed with a given volume of the gum mucilage in a planetary mixer and screened through 710im test sieves (Endocotts Limited, England). The resulting granules were dried to a constant weight in a hot air oven (Kotterman, Germany) at 50°C for 3 h. The mean moisture content was determined to be 3.1 ± 1.2% (w/w).

Preparation of tablets

The granules made from either *C. populnea* and *A. senegal* gum were compressed into flat faced tablets of mean weight 500 ± 6.23 mg, thickness 3.64 ± 0.33 mm, and diameter 12.5 ± 1.45 mm in a single punch tableting machine (Kilian and Co Frankfurt, Germany) at an arbitrary pressure load unit of 7. A 1% dispersion of magnesium stearate in chloroform was used to lubricate the die and punch surfaces prior to tableting to prevent sticking. In order to form tablets with centre through hole, a procedure for preparing tablets with a centre hole as previously described by Itiola and Pipel (1986) was adopted. Further details of the procedure for the formation of tablets with a centre through hole and the dimensions are as described by Okor et al. (1998).

Evaluation of the tablets

The consolidation of the tablets as given by the packing fraction (P_f) is given by the equation (3) below:

$$P_f = W/\pi r^2 t\lambda \quad (3)$$

where W is the mean weight of tablets (mg), r is the radius (m), and t is the thickness (m), *l* is the particle density of the paracetamol used in the tablet formulation. The determination was made using fluid displacement method to be 1.62 gcm^{-3}, (Sugita et al., 1995).

The tensile strength (T) of tablet which is a measure of the stress necessary to cause diametral fracture of the compact was determined from the mean data obtained from the hardness test carried out on the tablets (n = 10) using the Mosanto hardness tester according to Brook and Marshal (1968). The T values were computed from equation (4) below; (Fell and Newton, 1970):

$$T = 2P/\pi Dt \quad (4)$$

Where P is the load applied on the tablet that causes diametral fracture of the tablet of diameter, D, and t is the tablet thickness (m); n = 10. The T and T_0 values of the tablets formulated using either *A. senegal* or *C. populnea* gums were computed from the mean values of the tablet hardness data obtained and were in turn used to compute the brittle fracture tendency (BFI) values using equation (1) above.

RESULTS AND DISCUSSION

Effects of gum concentration on the viscosity index of the mucilage

The result of the effect of gum concentration on the viscosity index is shown in Figure 1. Generally, a common trend of increase in the gum concentration resulted in a corresponding increase in the viscosity index of the gum irrespective of binder type. This increase was more marked in *A. senegal* gum than with *C. populnea* mucilage. This may be attributed to interconnective structural differences in the polymers, which is more with *A. Senegal* than *C. populnea*. Such interconnectivity properties in a polymer have been indicated for strong and extensive polymer-polymer cohesion in the more viscous polymer and they are known to influence the intrinsic properties (Eichie and Okor, 2000).

An increase in the binder concentration resulted in a corresponding increase in the tensile strength. This effect was more marked with *A. senegal* than *C. populnea* thus indicating *A. senegal* as a more cohesive binder than *C. populnea*. Binders are known to impact plasticity and promote the formation of strong cohesive bonds between the particles. Previous studies reported that the greater

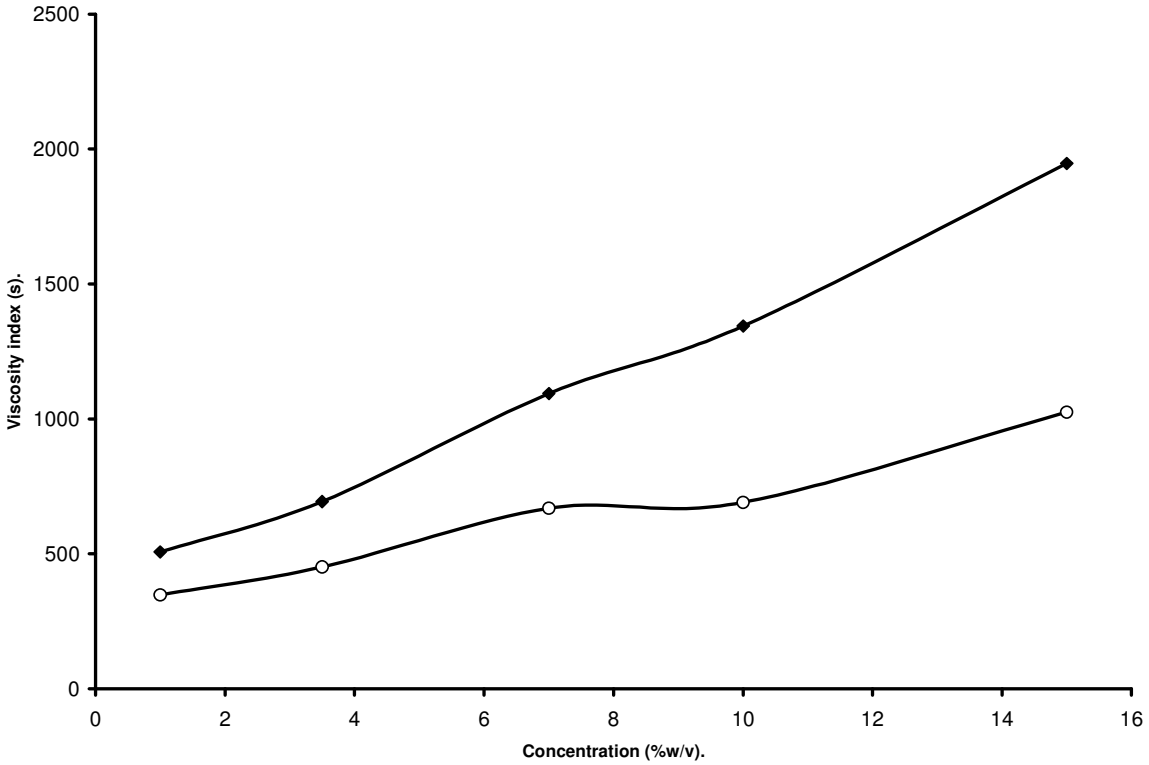

Figure 1. Effect of concentration of the gum on the viscosity index of *Accasia senegal* (■) and *Cissus populnea* (□).

Table 1. Effect of binder concentration on the tensile strength, packing fraction and brittle fracture index of tablets.

Binder concentration (%, w/w)	Tensile strength (MNm^{-2})	Packing fraction	Brittle fracture index
Accasia senegal			
1	0.48	0.22	0.36
3	0.60	0.31	0.31
7	0.64	0.39	0.31
10	0.69	0.41	0.29
15	0.74	0.52	0.28
Cissus populnea			
1	0.38	0.16	0.56
3	0.46	0.19	0.35
7	0.55	0.22	0.33
10	0.57	0.23	0.25
15	0.58	0.24	0.24

the plasticity of a material the greater the number and strength of bonds formed between its particles (Hiestand et al., 1977; Rees and Rue, 1978; Itiola and Pipel, 1986;Uhunmwangho et al., 2004). A similar effect has also been reported by Sheskey and Dasbach (1995) in their investigation of the effect of commonly used polymer binders on drug release and mechanical characteristic. The packing fractions of the resulting tablets were again higher with *A. senegal* tablets than *C. populnea*. The packing fraction is a measure of the degree of consolidation of the compact. This indicated that *A. senegal* tablets were more consolidated with closer packing of the particles than *C. populnea*.

The results of the effect of binder concentration on the brittle fracture index of the tablets are shown in Table 1. For both mucilages, an increase in binder concentration resulted in a decrease in the BFI values. However, this effect was more pronounced with *C. populnea* than *A. senegal*. The lower BFI values at higher binder concentrations are an indication of the mucilages to ameliorate

capping or lamination tendency of the tablets.

Conclusion

It has been shown here that *A. Senegal* mucilage formed harder compact with stronger inter particulate cohesive bonds than *C. populnea*. Again, tablets formed from *A. Senegal* mucilage showed greater consolidation than those from *C. populnea* as reflected by higher packing fraction thus indicating closer packing of the particles. Both gum mucilages displayed low BFI values at all concentrations employed in the study, thus indicating a high tendency to ameliorate capping or lamination upon ejection from the die wall. They both displayed good tableting characteristics and have high potentials for substitution for other more expensive binders like maize starch commonly used as binders in tablet formulation.

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