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Original Article

EVALUATION OF THE SUSPENDING PROPERTIES OF SHEA TREE GUM

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ABSTRACT

Objective: Shea gum is found in large quantities in the northern part of Ghana. Its use in the pharmaceutical industry has been limited by lack of research into the possible uses of the gum as a pharmaceutical excipient. This study seeks to investigate the use of shea gum as a suspending agent using paracetamol as a model drug.

Methods: The crude shea gum was collected, purified and used as a suspending agent to formulate paracetamol suspensions using gum concentrations of 1 %w/v, 2 %w/v, 3 % w/v and 4 % w/v. These suspensions with varying gum concentrations were compared with paracetamol suspensions containing same concentrations of acacia gum. The suspensions were all tested for their apparent viscosity, flow time, sedimentation volume over 42 d and ease of re-dispersibility.

Results: The apparent viscosities of both suspensions increased when the gum concentrations were increased. The flow times of the freshly prepared shea gum suspensions increased gradually with increasing concentration of gum. A similar trend was observed for suspensions made with acacia gum. For suspensions made with either gum, the volume of sediments was found to be inversely proportional to the concentration of the gum. However, the volume of sediments increased with time. The ease of re-dispersibility was directly proportional to the concentration of gum in suspensions containing either gum.

Conclusion: Shea gum was found to have suspending properties comparable to acacia gum. Shea gum can, therefore, be used in formulating oral suspensions of drugs.

Keywords: Suspension, Shea gum, Acacia gum

INTRODUCTION

Gums and mucilages are polysaccharide complexes formed from sugar and uronic acid units and are insoluble in alcohol but dissolve or swell in water [1]. They are usually formed from the cell wall or deposited on it in successive layers.

Gums are natural plant colloids that may be classified as anionic, non-ionic polysaccharides or salts of polysaccharides. They are translucent, amorphous substances that are frequently produced in higher plants as a protective substance after injury. The nature of the compounds that constitute gums influences the properties of different gums. Some plant gums such as gum arabic are soluble in water, dissolving to give clear solutions. Others like gum tragacanth produce mucilage by absorption of large quantities of water [2, 4].

Natural products like gums used as excipients have advantages of being biodegradable, biocompatible, nontoxic, and cheaper [3, 5]. Natural gums from plant origin have diverse application in drug formulation and delivery as binders, suspending agents, disintegrating agents, emulsifiers, gelling agents, thickening agents and many others depending on their exhibited properties [5].

Gums have been found useful in producing tablets of different mechanical strength and drug release properties for different pharmaceutical purposes. As a result of the versatile applications of gums, gums that have benefited from little or no scientific research are being studied and developed for various pharmaceutical uses.

Many gums such as acacia, cashew, albizia, xanthan, tragacanth, have been researched on and are currently used in several formulations. The shea tree can produce large amounts of gum that can serve as a cheaper replacement for synthetic gums if found to be useful in pharmaceutical formulations [6]. However, a little investigation of the potential economic uses of this gum, especially for pharmaceutical purposes has been conducted.

Despite the lack of scientific research on the shea tree gum, it has some traditional small-scale uses. Farmers, especially women, use shea tree gum to mend broken calabashes [7]. In Burkina Faso, Bobo musicians use it to repair cracked drums and punctured drumheads. The fresh latex is heated and mixed with palm oil to make glue [8, 9]. Furthermore, the gum is chewed as gum and made into balls for children to play with. The gum contains only 15-25% of carotene and is therefore, unsuitable for the manufacture of rubber [7, 10].

The shea tree gum is readily available all over the continent of Africa and in all the regions of Ghana. Almost all research on this tree has concentrated on the nuts which produce the oil used for the production of shea butter [7, 11].

The purification, physicochemical evaluation and the evaluation of the tablet formulation properties of shea gum have been reported, and this provides a basis for the use of the shea gum as a suspending agent [7].

This study seeks to evaluate the purified shea gum as a suspending agent using paracetamol as a model drug.

MATERIALS AND METHODS

Materials

Crude shea gum (CSG) was obtained from the wild as dried tears of the exudates from the stem bark of the *Vitellaria paradoxa* (family: Sapotaceae) plant in Bolgatanga in the Upper East Region of Ghana. It was authenticated at the Cocoa Research Institute of Ghana subsidiary research substation for the shea tree at Bole in the Northern Region of Ghana and given the serial number CRI/SG/0105.

Pure paracetamol powder (purity: 99.95 %)(Sigma, Aldrich, Damsta, Germany), diethyl ether (BDH, England), chloroform (BDH, England), benzoic acid (BDH, England), acacia powder (Sigma Aldirch, Damsta Germany) and ethanol (96%) (Scharlau, United Kingdom) All materials used were within their shelf lives and all reagents used were of analytical grade.

Graphs were plotted using Graph Pad Prism 5.

Instruments

Viscometer (Brookfield Engineering Labs, Stoughton USA), Hanna instruments pH 211 microprocessor pH meter, Adam-analytical weighing balance, WA 210; 210/0.0001g.

Method

Purification of Shea gum

The crude gum was air dried for 4 w until it became sufficiently brittle. The bark and other extraneous materials were scraped manually to clean the gum. The crude gum was further processed by pulverizing in a porcelain mortar with a pestle to obtain the powder. Parts of the powdered gum were used in some of the subsequent test and analysis as crude shea gum powder.

To purify the gum, 100 g of the crude gum powder was hydrated in 200 ml of distilled water for 14 d with intermittent stirring to allow enough time for dissolution of the gum material. The suspension obtained was strained into a beaker. The filtrate in the beaker was filtered to ensure that all debris was removed. Thereafter, the gum (100 g) was precipitated with 400 ml of 96 % ethanol. The precipitated gum was filtered and washed with diethyl ether and dried in the hot air oven at 40 °C for about 24 h. The dried purified gum was pulverized, and the powder sieved using sieve number 80. The purified gum was stored in an airtight container [7].

Preparation of Paracetamol Suspension

The paracetamol suspensions (2.4 0 %w/v) were prepared using gum concentrations of 1.0 %w/v, 2.0 %w/v, 3.0 %w/v and 4.0 %w/v each of acacia and purified shea gum powders using chloroform-water (ds) and benzoic acid (0.10 %) as preservatives [13,14]. The formula for formulating the suspension using 1.0 %w/v of gum is given in table 1. For suspensions with other gum concentrations, only the gum concentrations were varied in the formula in table 1.

Table 1: Formula for preparation of paracetamol suspension

Ingredient	Quantity
Paracetamol powder	2.4 g
Benzoic acid (0.1 %w/v)	0.1 g
Chloroform water (d/s)	50 ml
Gum (1 %w/v)	10 ml
Water to	100 ml

PH and rheological behavior of suspensions

The pH of each of the formulated suspensions was measured at 0 d and 42 d. The determinations were done in triplicates and their means and standard deviations recorded.

The viscosities of the suspensions formulated with the different concentrations of shea gum and acacia gum (1 %w/v, 2 %w/v, 3 %w/v and 4 %w/v) as suspending agents were determined using a viscometer at shear rates of 0.20 s^{-1}, 0.40 s^{-1}, 0.60 s^{-1}, 1.0 s^{-1} and 2.0 s^{-1}. The determinations were done in triplicates and the mean viscosities plotted against their respective shear rates.

Flow time and apparent viscosity

The time required for each formulated suspension (for each concentration of acacia and shea gum) to flow through a 10 ml pipette was determined using a stopwatch and the apparent viscosity (η) was calculated using the equation:

$$\eta \text{ (ml/s)} = \text{volume of pipette (ml)} / \text{flow time(s)}$$

The suspensions were stored for seven days and the procedure above was repeated for the stored suspensions. The apparent viscosity of each of the freshly formulated and stored suspensions was determined using the equation above [15, 16]. Triplicate determinations were made for the flow times and apparent viscosities and their mean values with their standard deviations calculated.

Sedimentation volume

50 ml of each formulated suspension (for each concentration of acacia and shea gum) was stored in a 50 ml measuring cylinder for 42 d at room temperature (25 °C). Observations were made at every hour for 6 h on the first day and then at every 72 h for 42 d. The sedimentation volume, F (%), was then calculated using the following equation: F % = 100Vu/Vo

Where Vu is the ultimate volume of the sediment and Vo is the original volume of the sediment [15, 16]. Triplicate determinations were done for Vu and Vo and their mean values used to calculate for F %.

Re-dispersion of suspensions

50 ml of each formulated suspension (for each concentration of acacia and shea gum) was kept in a measuring cylinder and stored at room temperature (25 °C.) for 42 d. After 42 d, the measuring cylinders were shaken vigorously to redistribute or re-disperse the sediments and the ease of re-dispersion was recorded [14]. This was done three times for each suspension.

RESULT AND DISCUSSION

PH and rheological behavior of suspensions

The pH of the various shea gum suspensions was either very weakly acidic or neutral (table 2). The pH of purified shea gum is about 7.133±0.120 [7]. Hence, the presence of the shea gum in the formulation was therefore responsible for the pH values recorded in table 2.

Table 2: pH of paracetamol suspensions formulated with shea gum

Shea gum concentration in suspension (%w/v)	PH at 0 d	PH at 42 d
1	6.59±0.020	6.55±0.010
2	6.78±0.012	6.67±0.030
3	7.01±0.010	6.99±0.010
4	7.50±0.030	7.06±0.040

pH readings given as mean±SD (n=3), Both gum suspensions showed a similar rheological pattern (fig. 1 and 2).

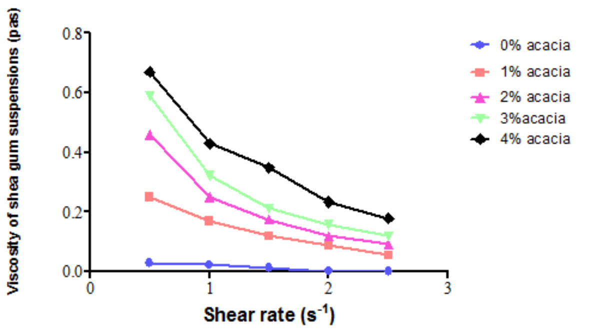

Fig. 1: Rheological behaviour of suspensions containing acacia gum

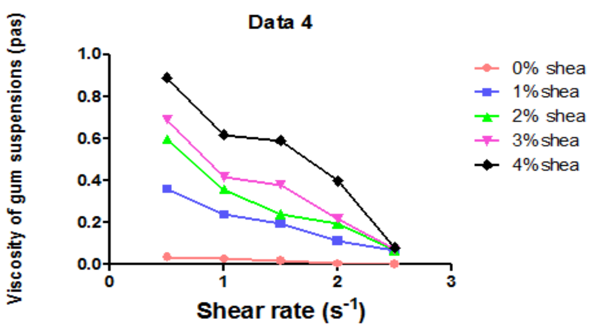

Fig. 2: Rheological behaviour of suspensions containing shea gum

Before the addition of either gum to the suspensions, the suspensions exhibited a Newtonian behaviour but upon addition of the gum at the concentrations studied, the flow pattern changed to pseudoplastic. However, the lower the concentration of the gum, the lesser the pseudoplastic behaviour observed. Pseudoplastic flow pattern is a desirable property in the formulation of suspensions enhancing re-dispersion and pourability of the suspension prior to administration.

Flow time and apparent viscosity

The flow time of the freshly prepared paracetamol suspension made with shea gum was found to be directly proportional to the concentration of gum. The time ranges from 9.30 s to 16.23 s for the various shea gum concentrations used (table 3). A similar trend was observed for suspensions made with acacia gum (table 3).

Table 3: Flow time and apparent viscosity of paracetamol suspensions containing Shea and acacia gum

Gum	Conc. (%w/v)	Flow time for freshly prepared suspension (s)	Apparent viscosity of freshly prepared suspension (ml/s)	Flow time for stored suspensions (s)	Apparent viscosity of stored suspensions (ml/s)
Shea gum	1.0	9.30±0.361	1.08	17.53±0.231	0.570
	2.0	11.50±0.200	0.87	28.27±2.146	0.35
	3.0	14.70±0.300	0.68	44.10±0.436	0.23
	4.0	16.23±0.416	0.62	97.10±0.361	0.10
Acacia gum	1.0	7.67±0.252	1.30	10.53±0.252	0.95
	2.0	10.07±0.058	0.99	24.50±0.200	0.41
	3.0	15.46±0.289	0.65	33.73±0.153	0.29
	4.0	16.60±0.265	0.60	63.63±0.306	0.16

Values for flow time and apparent viscosity are given as mean±SD (n=3).

It was observed that the apparent viscosities increased with an increase in gum concentration. The apparent viscosities of the freshly prepared suspensions were found to be higher than those of the stored suspensions (fig. 3). This means that the actual viscosities of the stored gum mucilage were higher than those of the freshly prepared mucilage.

Generally, natural polysaccharides may show a reduction in viscosity of their dispersions or solutions with age due to bacteria or mould growth. However, some other gums need a relatively longer time to hydrate and for such gums, the actual viscosities increase on storage [18]. From the results, it can be said that shea gum belongs to the latter group of gums since its actual viscosity increased upon storage.

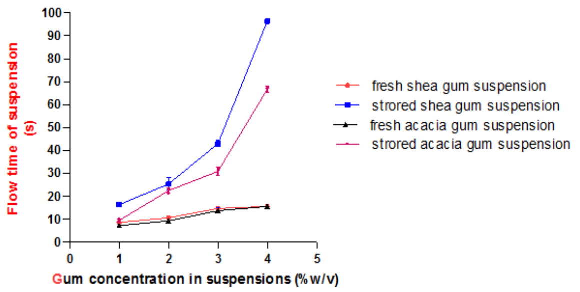

Fig. 3: Apparent viscosity of paracetamol suspension containing shea and acacia gum

An increase in the flow time of acacia gum suspensions as the storage time increased was observed (table 3). For example, for freshly prepared 1 %w/v acacia suspension, the flow time was 7.63 s but gave a flow time of 10.53 s after storage. Freshly prepared 1 %w/v shea gum suspension gave a flow time of 9.30 s and a flow time of 17.53 s after storage. This shows an increase in viscosity of the suspension upon storage. Some gums are well hydrated with time and their suspending ability increases with time.

For the same concentrations of shea and acacia gums, the shea gum suspensions were observed to have lower apparent viscosities than acacia gum (table 3). These imply that the suspendability of shea gum is better than that of acacia gum since shea gum will have a higher actual viscosity and will be able to keep suspended drugs longer in suspension for a dose to be poured than acacia gum.

Sedimentation volume

The volume of sediment was recorded hourly for 6 h on the first day (table 4) and then every 3 d or 72 h for 42 d (tables 5 and 6) for both gum suspensions. The 1 %w/v shea gum suspension attained its F % by the 6th day, both the 2 %w/v and 3 %w/v shea gum suspensions attained their F % by the 9th day and the 4 %w/v shea gum suspension, by the 30th day (table 6). Hence, the 4 %w/v shea gum suspension suspended the particles in suspension for the longest time compared to the other shea gum suspensions. There was no practical change in the volume of sediment, F %, values for same concentrations of shea gum (table 6). Hence, it can be inferred that upon storage the shea gum hydrates better than the acacia gum and is able to suspend the particles better than acacia.

Table 4: Sedimentation volume (F %) of gum suspensions over a period of 6 h

Time (h)	F % for the various acacia gum suspensions				F % for the various shea gum concentrations in suspensions			
	1.0 % w/v GS	2.0 % w/v GS	3.0 % w/v GS	4.0 % w/v GS	1.0 % w/v GS	2.0 % w/v GS	3.0 % w/v GS	4.0 % w/v GS
0	50	50	50	50	50	50	50	50
1	33	48	45	56	27	31	40	47
2	30	42	40	54	25	28	33	43
3	24	35	33	47	20	23	31	41
4	20	35	32	45	16	18	27	41
5	20	25	32	43	16	15	23	38
6	20	35	32	42	13	15	21	37

Sedimentation volume, $F\% = 100Vu / Vo$, where Vu is the ultimate volume of the sediment and Vo is the original volume of the sediment [15,16]. GS means gum suspension.

Table 5: Sedimentation volume (F %) of the acacia gum suspensions over 42 d

Time (d)	1.0 % w/v GS	2.0 % w/v GS	3.0 % w/v GS	4.0 % w/v GS
0	50.0	50.0	50.0	50.0
3	12.0	30.0	24.0	40.0
6	12.0	27.0	21.0	38.0
9	12.0	27.0	19.0	37.0
12	12.0	27.0	19.0	37.0
15	12.0	25.0	19.0	34.0
18	12.0	25.0	19.0	30.0
21	12.0	25.0	19.0	30.0
24	12.0	25.0	19.0	30.0
27	12.0	25.0	19.0	30.0
30	12.0	25.0	19.0	30.0
33	12.0	25.0	19.0	30.0
36	12.0	25.0	19.0	30.0
39	12.0	25.0	19.0	30.0
42	12.0	25.0	19.0	30.0

Sedimentation volume, $F\% = 100Vu\ /\ Vo$, where Vu is the ultimate volume of the sediment and Vo is the original volume of the sediment [15,16]. GS means gum suspension.

Table 6: Sedimentation volume (F %) of the Shea gum suspensions over 42 d

Time (d)	1.0 % w/v GS	2.0 % w/v GS	3.0 % w/v GS	4.0 % w/v GS
0	50.0	50.0	50.0	50.0
3	11.0	13.0	20.0	34.0
6	10.0	12.0	18.0	30.0
9	10.0	10.0	17.0	28.0
12	10.0	10.0	17.0	28.0
15	10.0	10.0	17.0	28.0
18	10.0	10.0	17.0	28.0
21	10.0	10.0	17.0	28.0
24	10.0	10.0	17.0	28.0
27	10.0	10.0	17.0	28.0
30	10.0	10.0	17.0	27.0
33	10.0	10.0	17.0	27.0
36	10.0	10.0	17.0	27.0
39	10.0	10.0	17.0	27.0
42	10.0	10.0	17.0	27.0

Sedimentation volume, F % = 100 Vu/Vo, where Vu is the ultimate volume of the sediment and Vo is the original volume of the sediment [15, 16]. GS means gum suspension.

Re-dispersion of suspensions

After storage and re-dispersion of acacia gum suspensions, the rate of sedimentation decreased drastically as compared to that of the freshly prepared suspension. This goes to show that the suspending ability of acacia gum increases with time.

Before re-dispersion, the supernatant was clear for shea gum suspension. With the re-dispersion of shea gum suspension, there was not much change in the rate of sedimentation, but it was observed that some particles were still suspended. The rate of sedimentation of acacia gum suspensions was somewhat lower than that of the shea gum suspensions.

Shea gum suspensions with gum concentrations of 1.0 % w/v and 2.0 % w/v were easily re-dispersed, but concentrations of 3.0 %w/v and 4.0 % w/v re-dispersed with much difficulty (table 7). This can be attributed to tighter packing of the gum particles. The addition of deflocculating agent may reduce the tight packing nature of the shea gum. With the acacia gum suspensions, only the 4.0 %w/v gum concentration dispersed with much difficulty. The other acacia gum suspensions were easily re-dispersed (table 8).

Table 7: Summary of re-dispersibility of shea gum suspension after 42 d

Gum concentration (% w/v)	Shea gum suspension
1.0	Re-disperses easily after shaking
2.0	Re-disperses easily after shaking
3.0	Re-disperses after vigorous shaking
4.0	Re-disperses after vigorous shaking

Table 8: Summary of re-dispersibility of acacia gum suspension after 42 d

Gum concentration (% w/v)	Acacia gum suspension
1.0	Re-disperses easily after shaking
2.0	Re-disperses easily after shaking
3.0	Re-disperse easily after shaking
4.0	Re-disperses after vigorous shaking

CONCLUSION

The shea gum was found to have suspending abilities and the flow time was found to be directly proportional to the gum concentration.

The flow times of the stored suspensions of both gums were found to increase proportionally to the times of storage. The apparent viscosities were found to be directly proportional to the concentrations of the gums, and the ease of re-dispersibility was directly proportional to the gum concentration.

The suspending abilities of shea gum were found to be comparable to the suspending abilities of acacia gum of the same concentration with respect to the parameters investigated.

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CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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