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EVALUATION OF THE EMULSIFYING POTENTIAL OF SHEA TREE GUM

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ABSTRACT

The emulsifying potential of shea tree gum in pharmaceutical emulsions was investigated. This was done by formulating emulsions with different types of oils using the wet and dry gum methods. The ratio of oil to water to gum needed for the preparation of stable primary emulsions was determined. All the primary emulsions formulated creamed readily on dilution. The stability of paraffin oil emulsions was assessed and reduction in creaming was attempted through homogenization, addition of a surfactant and a thickening agent. Addition of a small quantity of Tween 60 (0.001– 0.002% w/v) which is very close to the critical micelle concentration of the surfactant stabilised the emulsions. Homogenisation and addition of

xanthan gum, a thickening agent, had no marked stabilising effect. The degree of stability of the stable emulsions was also investigated by centrifugation using the emulsion stability factor 'S' which gave a 100% emulsion stability indicating a very stable emulsion when stabilized with 0.002% w/v Tween 60. In addition, the apparent viscosities determined for the emulsions showed that there was no change in viscosity or turbidity during the 12 w observations. Also the size index, R, values were found to be within the range of 0.27 -0.29 which indicate that the emulsions were stable and the size of the droplets were relatively small. At the same concentration, the shea gum was found to produce more stable emulsions with 'R' values less than that of acacia gum (0.37-0.38) at the same concentration.

KEYWORDS: Shea gum, acacia gum, emulsion, Tween 60.

INTRODUCTION

Gums are by-products obtained from the metabolic mechanisms of plants. Natural gums are readily available and are either water soluble or absorb water to form a viscous solution.^[1]

Natural gums are known to be either acidic or neutral as there are no naturally-occurring basic gums.^[1] They have the advantage of being hydrophilic, relatively inexpensive, generally non-toxic and biodegradable. They are however, more susceptible to microbial contamination, uncontrolled hydration, batch to batch variation and prone to viscosity reduction upon storage than synthetic gums.^[2]

Gums have been widely used as tablet binders, emulgents and thickeners in cosmetics and suspensions as film-forming agents and transitional colloids.^[2]

Commercially useful natural gums are obtained from sources as diverse as marine (alginate, agar, carrageenan), seed (guar gum, locust bean, amylose), tree exudates (acacia, khaya, albizia, tragacanth), animal origin (chondroitin sulphate, chitin, chitosan) and microbial (dextran, xanthan, emulsan).^[3]

To make up for the limited availability and higher cost of some of these commercial gums, efforts have been made to find and exploit alternative naturally occurring gums that are cheap and also have very good pharmaceutical applications.

Many natural gums have been investigated for their emulsifying properties in recent years. A study on the mucilage extracted from the kernels of *Irvingia gabonensis* (Family: Irvingiaceae) showed that, it was a better emulsifying agent than acacia and tragacanth at lower concentrations.^[4] The purified gum extracted from the tubers of *Ferula gumosa* (Family: Apiaceae) was found to reduce surface and interfacial tension of soybean oil emulsions.^[5]

The stem of the shea tree, *Vitellaria paradoxa* (Family: Sapotaceae), has deep fissures which are usually covered with gums. Gums can also be found in areas of injury on the stem as well as on broken twigs or petioles. The shea tree gum is a whitish liquid when freshly produced and it takes about 1-3 h to solidify to a malleable solid for few days but becomes very hard and breaks with glassy appearance as it ages on the tree. The gum has a bland taste and has no distinctive smell to differentiate it from some resins and oleo-resins. The gum has been reported to be useful in tablet formulation in recent years.^[6]

This study therefore seeks to investigate the emulsifying potential of the shea tree gum.

MATERIALS AND METHOD

Materials

Crude shea gum (CSG) was obtained from the wild as partially dried tears of exudates from the stem bark of the plant *V. paradoxa* 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. 96% ethanol (Shenstone, England), paraffin oil (Sigma-Aldrich, St Louis, Missouri, USA), castor oil (Sigma-Aldrich, St Louis, Missouri, USA) and peppermint oil (Sigma-Aldrich, St Louis, Missouri, USA), Tween 60 (Sigma-Aldrich, St Louis, Missouri, USA).

Instruments

Brookfield viscometer spindle-LV2 (Brookfield LVII, USA), UV-Visible Spectrophotometer (UV-1601, Shimadzu, Japan), Centrifuge (Remi, C-24BL, Remi Instruments Ltd., Mumbai, India).

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 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.^[6] The purified gum was stored in an airtight container.

Preparation of primary emulsions

Different ratios of oil, water and gum were investigated to determine which ratio will give the most stable primary emulsions of castor oil (fixed oil), paraffin oil (mineral oil) and peppermint oil (volatile oil). The castor oil, paraffin oil and peppermint oil emulsions investigated contained 16.70 – 28.60% w/v, 16.70 – 27.30% w/v and 18.0 – 35.30% w/v of shea gum respectively. The emulsions were prepared by employing the wet gum and dry gum techniques of emulsion formation.

For the wet gum method, the specified amount of water was added to the purified gum and triturated in a glass mortar. The oil was added drop-wise to the gum solution and triturated till the hearing of a cracking sound upon forming the primary emulsion.

For the dry gum method, the stated amount of oil was triturated with the gum followed by drop-wise addition of water till the hearing of a cracking sound. The primary emulsions prepared were observed for consistency and phase separation.^[7]

Stabilization of the primary emulsions

Paraffin oil emulsions containing 20% w/v shea gum were prepared using the wet gum method. 20% w/v of shea gum was chosen after several trials. 100 ml of the paraffin oil emulsion was transferred into a blender and homogenized for 3 min. Stabilization of the 100 ml paraffin oil emulsions was further attempted by the addition of a thickening agent (xanthan gum: 40 ml, 0.01 – 0.80% w/v) and a surfactant (Tween 60: 15 ml, 0.001 - 0.04% v/v) followed in each case by homogenization in a blender for 3 min. The emulsions were transferred into plain bottles, covered and stored at room temperature for observation.^[7]

Centrifugal method of evaluating emulsion stability

Samples of the emulsions formulated were put into the test tubes of the centrifuge and controlled to a temperature of 25⁰C for 10 min at 3500 rpm.

The emulsion stability (S) was calculated using the formula:

$$S = [(V_0 - V) / V_0] \times 100\%$$

Where: S - emulsion stability %, V₀ – volume of emulsion centrifuged (ml), V- volume of the phase given off (ml).^[8]

Measurement of emulsion viscosity

The emulsions were stored at room temperature for 12 w and the viscosity of the emulsions were measured with the viscometer at 0 w, 6 w and 12 w. The viscosities were determined three times and the mean viscosities and their standard deviations calculated.

Measurement of emulsion turbidity

1 in 1000 dilutions of all the formulated emulsions were prepared and their absorbances measured at 400 nm 800 nm. The absorbances were determined three times and the mean absorbances and their standard deviations determined. From the absorbance values, the opacity and the size index (R) for the emulsion were determined for every emulsion. The ratio of the mean absorbance at 800 nm to the mean absorbance at 400 nm for a particular emulsion gave R.^[9]

RESULTS AND DISCUSSION

Different ratios of oil, water and shea gum were used in the preparation of the primary emulsions. Table 1 shows the optimal ratio of oil to water to gum required for the preparation of stable primary emulsions of castor oil, paraffin oil and peppermint oil.

Table 1: Composition of stable primary emulsions prepared with shea gum using the wet gum method

TYPE OF OIL	COMPOSITION OF EMULSION (%w/v)		
	OIL	WATER	GUM
castor oil	50	20	30
peppermint oil	57	29	14
Paraffin Oil	50	25	25

The primary emulsion of peppermint oil formed was rather unstable and creamed on standing after a short time (i.e. less than 1 h). The wet gum method produced better and more stable castor oil and paraffin oil primary emulsions while the dry gum method produced only stable primary emulsions of paraffin oil. All the primary emulsions formed exhibited massive creaming when they were diluted with water. There was therefore the need to stabilize them to minimise the incidence of creaming.

Creaming, unlike cracking, is a reversible process as the emulsion is readily reformed after shaking the container. However, creaming of emulsions makes the pharmaceutical product physically not acceptable. Creaming of emulsions occurs when the dispersed phase is lighter than the continuous phase. Techniques such as homogenization, addition of a thickening

agent or reduction of the interfacial tension with a surfactant are commonly used to reduce creaming in emulsions. Homogenization ensures the distribution of the gum (stabilizer) over the surface of the dispersed phase particles thus reducing particle coalescence.

Inclusion of thickening agents in the continuous phase of emulsions produces non-Newtonian systems that will have a high residual or zero shear viscosity.^[10]

Surfactants reduce the interfacial tension between the phases as well as form a barrier between the phases against coalescence.

At 20% w/v shea gum concentration, the paraffin oil emulsions continued to exhibit marked creaming after homogenisation. Also, addition of 40 ml of 0.01 – 0.80% w/v xanthan gum followed by homogenization did not have any marked effect on the level of creaming of the emulsions (Table 2).

Table 2: Stabilisation of paraffin oil emulsions with xanthan gum followed by homogenisation

Concentration of xanthan gum used (% w/v)	Observation
0.01	Creaming
0.02	Creaming
0.04	Marked Creaming
0.08	Marked Creaming
0.10	Marked Creaming
0.20	Marked Creaming
0.40	Marked Creaming
0.80	Marked Creaming

The level of creaming observed for emulsions with gum concentrations of 0.01% w/v and 0.02% w/v was similar but less than those produced by the other emulsions. The other emulsions with higher gum concentrations (i.e. 0.04 -0.08% w/v) gave a similar observation.

Tween 60 is a non-ionic surfactant with specific gravity of 1.044 g/ml, a critical micelle concentration (CMC) of 27 mg/l, micelle molecular weight of 1309 and a hydrophile lipophile balance (HLB) of 14.9.^[11] Addition of Tween 60 to the paraffin oil emulsions followed by homogenisation produced interesting observations. When Tween 60 (15 ml; 0.02 - 0.080% v/v) was added to the emulsions followed by homogenisation, the extent of creaming of the paraffin oil emulsions was rather enhanced. However, addition of Tween 60 (15 ml; 0.001 – 0.005% v/v) caused a significant reduction in creaming of the emulsions after homogenization (Table 3).

Table 3: Stabilisation of paraffin oil emulsions with Tween 60 followed by homogenization

Concentration of Tween 60 (% v/v)	Observation
0.001	Very little creaming
0.002	Very little creaming
0.004	Reduced creaming. Gum not thrown out.
0.008	Reduced creaming. Gum not thrown out.
0.010	Creaming was visible with the formation of two layers.
0.020	Marked creaming. Gum not thrown out onto the surface.
0.040	Marked creaming. Gum not thrown out onto the surface.

Tween 60 concentrations of 0.001% v/v and 0.002% v/v, 0.004% v/v and 0.008% v/v and 0.020% v/v and 0.040% v/v gave similar observations. The level of creaming seen for 0.020% v/v and 0.040% v/v, which was the highest, was more than that of 0.010% v/v. The creaming observed for 0.004% v/v and 0.008% v/v was more than that of 0.001% v/v and 0.002% v/v. The creaming observed for 0.010% v/v was more than those produced by the emulsions with lower Tween 60 concentrations.

Thus concentrations of Tween 60 close to its CMC will produce very stable emulsions.

The investigations of the stability of the emulsions using the method of centrifugation gave emulsion stability (S) of 100%. No phase separation was seen for the emulsions investigated.

The shea gum and acacia gum emulsions were stable during the 12 w since there were no significant changes in their viscosities and absorbances (Table 4).

Table 4: Viscosity and turbidity measurement of emulsions stabilized with 0.002 %v/v Tween 60

Parameters	Emulsion with shea gum			Emulsion with acacia gum		
	0	6	12	0	6	12
Time (w)						
Viscosity (cp)	22.13 ±0.647	22.14 ±0.64	21.87 ±0.63	22.65 ±0.63	23.87 ±0.63	22.23 ±0.33
Absorbance at 400 nm	0.541 ±0.0011	0.587 ±0.0011	0.591 ±0.0011	0.417 ±0.0011	0.419 ±0.0012	0.425 ±0.0011
Absorbance at 800 nm	0.150 ±0.0011	0.169 ±0.0014	0.172 ±0.0011	0.156 ±0.0011	0.156 ±0.0012	0.165 ±0.0011
Size index(R)	0.2773	0.2879	0.2910	0.3741	0.3723	0.3880

The emulsions used in Table 4 were prepared using oil: water: gum ratio of 10:20:100 in either case. The values for viscosity and absorbance are given as mean \pm SD (n = 3). R is the ratio of the mean absorbance at 800 nm to the mean absorbance at 400 nm for a particular emulsion at a particular time. 0.002% v/v Tween 60 was chosen to stabilize the emulsions used for the viscosity and turbidity measurements because it gave the most stable emulsion (Table 3).

'R' values of 0.2- 0.5 indicate high stability of emulsions and relatively small droplet sizes while 'R' values greater than 0.6 indicate low stability of emulsion and relatively large droplet sizes.^[12]

The R values for the shea gum emulsions were lower than those of the acacia emulsions suggesting that the shea gum is more likely to form more stable emulsions than acacia gum.

CONCLUSION

The result of the study showed that shea gum has emulsifying properties. The emulsifying properties were best seen at a gum concentration of 20% w/v.

The emulsions prepared with shea gum may be stabilized with Tween 60 at a concentration of 0.002% w/v.

Emulsions formulated with shea gum were found to be more stable than emulsions formulated with acacia gum at the same concentration.

Shea gum can therefore be used as an emulsifying agent in the formulation of emulsions.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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