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Full Length Research Paper

Suspending properties of natural gums extracted from *Abelmuscus esculentus* pod and *Chrysophyllum albidium* fruit

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The aim of this study was to extend the application of gum extracted from *Abelmuscus esculentus* pods (AEG), ripped *Chrysophyllum albidium* fruit (RCAG) and unripped *C. albidium* fruit (UCAG) to pharmaceutical suspensions. The extracted gums, gelatin and compound tragacanth were used to formulate Paracetamol suspension in concentrations of 0.5 to 4.0% w/v. The sedimentation rates, sedimentation volume, ease of re-dispersibility and viscosity of the suspension were studied as assessment parameters. The rank order of the suspending ability of the suspendants as evaluated by the sedimentation volume was AEG > gelatin > compound tragacanth > RCAG. Suspensions formulated with RCAG has comparative viscosity with those containing gelatin and compound tragacanth; however, Paracetamol suspensions having AEG has significantly higher viscosity ($p<0.05$) when compared with those containing RCAG, gelatin and compound tragacanth. The flow rate decreases with increase in the concentration of the suspending agent and increase in the viscosity. Paracetamol suspensions containing RCAG were easily redispersible with minimum agitation and are stable enough for adequate dose withdrawal. The viscosity of formulations containing AEG decreases with increased speed of agitation. On the basis of these findings, pharmaceutical suspension containing *A. esculentus* and *C. albidium* gums as suspending agents may be applied as liquid drug delivery system for pediatric and geriatric patients.

Key words: Paracetamol suspension, suspending agents, okra gum, *Chrysophyllum albidium* gum, sedimentation volume, viscosity.

INTRODUCTION

Suspensions are an important pharmaceutical dosage form that is still widely in use. Owing to their versatility they are often used in situations where the patients are unable to swallow tablets or capsules (Marriot et al.,

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2010). Pharmaceutical suspensions are dispersions of an insoluble drug in an aqueous or non-aqueous continuous phase and like other disperse systems they are thermodynamically unstable. Thus, it is necessary to include in the dosage form a stabilizer or suspending agent. A well-formulated suspension should easily be re-suspended when moderately agitated and should allow uniform and accurate doses of the medicament to be withdrawn throughout the period of medication. Suspending agents are used in formulations to help the dispersed phase to remain suspended long enough when shaken and assist in easy re-dispersion of settled particles on standing (Ogaji, 2011). These have the benefit that consistent withdrawal of uniform doses is possible throughout the medication period. Natural gums from *Irvingia gabonnsis, Albizia zygia, Grewia mollis* and *Khaya grandifolia* have been reported to provide the needed platform for some of the quality attributes of a suspension due to their ability to swell when in contact with water and their viscous nature (Ndjouenkeu et al., 1996; Femi-Oyewo et al., 2004; Isimi et al., 2000; Ogaji, 2011; Nep and Conway, 2010). Natural gums are generally biodegradable, cheap, easily available, effective, and ecofriendly as compared to synthetic and semi-synthetic materials as pharmaceutical excipients (Prasad et al., 1998; Rana et al., 2011; Bakre and Abimbola, 2013).

Okra (*Abelmuscus esculentus*) is an annual or perennial herbaceous plant, growing up to 2 m tall straight up with very little phototropism. The pod could be green, red or purple, long, slender or chunky with numerous ridges running along the length of the pod. The pod varies in length from a few to about 7 cm in length and 1 to 4 cm in width. Okra plant grows very fast; therefore, it must be harvested every two days. Although, the crop can be grown on all soil types; sandy loam soils high in organic matter are the most desirable. Okra is among the most heat-and drought-tolerant vegetables in the world. Once established, it can survive severe drought conditions. The edible pods are used in soups and as a vegetable (Smith et al., 2002).

Chrysophyllum albidium fruit is almost spherical, with a slight point at the tip. There are 3 to 5 seeds brown, shiny seeds (1-1.5 × 2 cm), arranged in a star-shaped pattern in the yellow pulp. The seeds have a hard seed coat and the fruit turns from greenish grey when immature to orange, pink or yellow when ripe (Smith et al., 2002)

Although some works (Boyinbode and Iranloye, 1986; Odeku and Akinlosotu, 1997) had been carried out on the gums extracted from okra and *C. albidium* gums as excipients in pharmaceutical formulations, it appears that no work has been done to assess the suitability of these gums as suspending agents in paracetamol suspension as compared to the relatively common natural agents like gelatin and compound tragacanth gum. Paracetamol was chosen for this investigation because it is a practically insoluble drug which would require a suspending agent to be prepared as a liquid dosage form.

METHODOLOGY

Materials

The materials used were paracetamol powder (Spectum chemicals, USA), benzoic acid, acetone (BDH Chemicals, UK), compound tragacanth gum (Searl Co., England), and gelatin (Merck, Germany). Water was double distilled and every other chemical was of analytical grade.

Extraction of gums

Okra gum was extracted from the pods of *A. esculentus* fruit using the method of Onunkwo and Mba (1996). The fruits were cleaned, washed, sliced, crushed and then macerated in distilled water for 10 h with intermittent stirring. The mucilage was filtered through a white muslin cloth to extract the gum and acetone was added to precipitate the extracted gum. The gum obtained labeled as AEG was then filtered under vacuum to remove acetone and dried in a dessicator. The same procedure was used for the extraction of gum from ripped (RCAG) and unripped (UCAG) *C. albidium* fruit.

Formulation of paracetamol suspension

A 0.5 g quantity of compound tragacanth powder and 5 g of paracetamol were triturated together with 50 ml of water to form a smooth paste. The mixture was transferred into a 100 ml of measuring cylinder made up to volume with distilled water and then shaken vigorously for 2 min (thus making 0.5% w/v of the gum in the preparation). The suspension contains 0.1% w/v benzoic acid as preservative. The procedure was repeated using 1.5, 2.5, 3.0, and 4.0 g of compound tragacanth powder. The aforementioned procedure was repeated with gelatin, okra and *C. albidium* gums

Phytochemical analysis

Phytochemical analysis was carried out following established procedures in the British Pharmacopoiea (1998).

Determination of sedimentation volume and rate

Each suspension (50 ml) was stored in a 50 ml measuring cylinder for 7 days at 35°C. Observations were made at every hour for 7 h and then every 24 h for 7 days. The sedimentation volume, F (%), was then calculated using the following equation.

$$F = 100\ Vu/Vo \qquad (1)$$

where Vu is the ultimate volume of the sediment and Vo is the original volume of the suspension.

Rheological assessment using Brookfield viscometer

Viscosities of the prepared suspensions were determined using a Brookfield Synchro-electric viscometer; model LVF (Brookfield Laboratories, Massachusetts). Different concentrations of the

prepared suspensions were put separately in a 600 ml beaker, appropriate enough to immerse the spindle groove in the fluid. Viscosity values at rotational speeds of 10, 20, 50, and 100 rpm were determined at room temperature. All determinations were made in at least triplicate and the results obtained are expressed as the mean values.

Determination of flow rate

The time required for each suspension sample to flow through a 10 ml pipette was determined and the apparent viscosity (Ƞ) was calculated using the equation:

Flow rate Ƞ = Volume of pipette (ml) / Flow time (s) (2)

Ease of re-dispersibility of formulated suspensions

Fifty milliliters quantities of the formulated suspensions were poured into bottles, stoppered and kept on a vibration free platform. The suspensions were shaken 3 times, manually by hand after 7 days to find out how much of it was re-dispersed.

RESULTS AND DISCUSSION

Phytochemical analysis of gums

Phytochemical tests carried out on RCAG and AEG gums confirmed the absence of alkaloids, anthraquinones and carbohydrates in accordance with the belief that gums do not contain carbohydrates, but complex acids built up of less common sugar (Femi-Oyewo et al., 2004).

Effects of various suspending agents on the sedimentation volume of paracetamol suspension

Table 1 shows the sedimentation volume of the paracetamol suspensions at 0 to 4.0% w/v suspending agents for 7 days. The internal phase settled rapidly within the first 1 h of preparation for suspensions containing RCAG and compound tragacanth and settled constantly over the next 7 days. Paracetamol suspension formulated with AEG exhibited the highest sedimentation volume while suspensions containing UCAG had the lowest sedimentation volume. High sedimentation volume is an indication that although the internal phase particles have settled, as would be expected with suspensions, the inter particle attraction and bonding were loose and not strong enough to form hard cake during the study period. The result suggested that differences in the sedimentation profiles was probably due more to the suspending agent used than the properties of the internal phase. The rank order of the suspending ability of the suspendants as evaluated by the sedimentation volume was AEG > Gelatin > Compound Tragacanth > RCAG > UCAG.

Most pharmaceutically useful polymers contain polar functional groups that are separated by a hydrocarbon backbone. This structure provides the polymer molecule with many active centres that permit interaction with a particle surface. At very low concentration of polymer, a large number of sites on the surface of the dispersed solids are available for adsorption of the polymer. The simultaneous adsorption of the polymer molecule on to the surfaces of different particles creates a bridge. At a high concentration of polymer, there is complete coverage of the particles by the polymer and insufficient binding sites remain on the particles to form interparticulate bridges. This consequently leads to deflocculation due to formation of adsorbed layers of polymer on different particles (Gennero, 2000). Generally, at higher gum concentration of 3.0 and 4.0% w/v, it was observed that the suspensions showed low sedimentation volume.

Effects of types of suspending agents and concentrations on the viscosity, flow rate and re-dispersibility of paracetamol suspension

The viscosity of suspensions is a factor of great importance for stability and pourability of suspensions. Suspensions are the least stable dosage form due to sedimentation and cake formation. The viscosity of different concentrations of the test gums are as shown in Table 2.

Suspensions formulated with RCAG have comparative viscosity with those containing gelatin and compound tragacanth. However, paracetamol suspensions containing AEG have significantly higher viscosity ($p<0.05$) than those containing RCAG, gelatin and compound tragacanth. This suggests that paracetamol suspensions formulated with AEG have a low terminal settling velocity; thus, the dispersed phase settles at a slower rate and remains dispersed for a longer time yielding higher stability to the formulated suspension. As the concentration of the gum increases, the viscosity of the paracetamol suspension increases. This suggests that paracetamol suspension with higher gum concentration is expected to give a suspension that settles slowly. The flow rate decreases with increase in the concentration of the suspending agent and increase in the viscosity. Paracetamol suspension containing RCAG and UCAG were easily re-dispersible with minimum agitation and are stable enough for adequate dose withdrawal.

Effect of speed of rotation on the viscosity of gums

Figure 1 shows the effect of speed of rotation on the

Table 1. Values of the sedimentation volume of paracetamol suspension using various suspending agents.

Concentration (g/ml)		Sedimentation volume (%)														
		Time (h)								Days						
		0	1	2	3	4	5	6	7	1	2	3	4	5	6	7
	0.0	100	22	22	21	21	21	21	21	20	19	18	18	18	17	17
	0.5	100	16	14	14	13	13	13	13	12	12	12	12	12	12	12
	1.5	100	22	22	22	22	22	22	22	21	20	20	20	20	20	20
RCAG	2.5	100	20	20	20	20	20	20	20	19	19	18	18	18	18	18
	3.0	100	18	18	18	18	18	18	18	18	18	16	16	16	16	16
	4.0	100	28	28	27	27	27	27	26	26	25	25	25	24	24	24
	0.5	100	18	18	18	18	18	18	18	18	18	17	16	16	16	16
	1.5	100	20	20	20	20	20	20	20	20	20	18	18	18	18	18
UCAG	2.5	100	06	06	06	06	06	06	06	06	05	04	04	04	04	04
	3.0	100	12	12	10	10	09	09	09	08	08	08	08	08	08	08
	4.0	100	10	10	10	10	10	10	10	09	06	06	06	06	06	06
	0.5	100	100	100	100	99	98	98	97	96	96	93	80	74	74	74
	1.5	100	100	100	100	98	98	98	96	95	94	92	90	84	80	80
AEG	2.5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	3.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	4.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	0.5	100	60	60	58	58	57	56	55	55	54	54	53	50	50	50
	1.5	100	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Gelatin	2.5	100	80	80	80	80	80	80	80	80	80	80	80	80	80	80
	3.0	100	10	10	10	10	10	10	10	10	10	09	08	08	08	08
	4.0	100	12	12	12	12	10	10	10	10	10	10	10	10	10	10
	0.5	100	22	22	21	20	20	20	20	20	19	19	19	18	17	17
	1.5	100	32	32	30	30	30	30	30	28	24	24	24	23	23	23
Compound tragacanth	2.5	100	34	34	32	32	30	30	30	30	28	28	27	27	26	26
	3.0	100	40	40	32	32	30	30	30	29	29	28	28	28	28	27
	4.0	100	48	47	36	34	34	34	34	33	33	33	32	32	31	31

Table 2. Effects of the type and concentration of suspending agents on the flow rate (ml/s) and viscosity at 50 rpm (centipoise) of Paracetamol suspensions.

Suspending agent	Concentration (% w/v)	Flow rate (ml/s)	Viscosity (Centi poise)	Re-dispersibility
	0.5	1.00	6.00	+ + +
	1.5	0.95	4.00	+ + +
RCAG	2.5	0.91	4.00	+ + +
	3.0	0.89	6.00	+ + +
	4.0	0.92	6.00	+ +
UCAG	0.5	0.73	4.00	+ + +

Table 2. Cont'd

	1.5	0.75	6.00	+ + +
	2.5	0.65	6.00	+ + +
	3.0	0.57	6.00	+ + +
	4.0	0.47	6.00	+ + +
	0.5	0.07	6.70	+ + +
	1.5	0.06	8.38	+ + +
AEG	2.5	***	20.00	------
	3.0	***	***	------
	4.0	***	***	------
	0.5	0.94	6.00	+ + +
	1.5	0.89	6.00	+ + +
Gelatin	2.5	0.87	6.00	+ + +
	3.0	0.80	8.00	+ + +
	4.0	0.74	8.00	+ + +
	0.5	1.00	6.00	+ + +
	1.5	1.00	6.00	+ + +
Compound tragacanth	2.5	0.83	8.00	+ + +
	3.0	0.83	8.00	+ + +
	4.0	0.77	20.00	+ +

***: Too viscous to be determined. +++: Easily re dispersible with minimum agitation and stable enough for adequate dose withdrawal. ++: Re-dispersible with vigorous agitation and stable enough for adequate dose withdrawal. ---: Not re dispersible, formed hard cake.

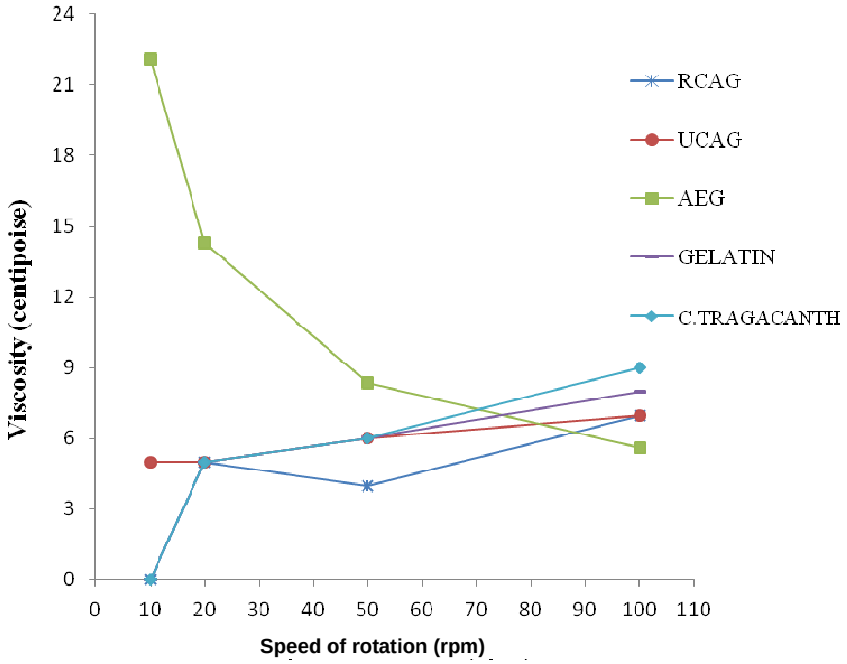

Figure 1. Effect of speed of rotation on the viscosity of paracetamol suspension formulated with 1.5% w/v concentrations of test gums.

viscosity of paracetamol suspension formulated with 1.5% w/v concentrations of test gums.

The decreased viscosity values observed with increasing speed of rotation for formulations containing AEG could be attributed to the nature of the mixture which may likely be pseudoplastic. This implies that with minimum agitation the suspension will be easily re-dispersed and a stable dose can be withdrawn. However, the viscosity of formulations containing RCAG, UCAG, gelatin and compound tragacanth was proportional to the speed of agitation

Conclusions

On the basis of these findings, *A. esculentus* and *C. albidium* may find application as suspending agents in pharmaceutical suspensions for pediatric and geriatric patients

Conflict of interest

The authors declare that they have no conflict of interests.

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