Effect of Natural Gum from *Triculia Africana* Seeds on Pharmaceutical Suspension Formulation

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Abstract: **Aceclofenac suspensions were prepared with varying concentrations (0.5, 1.0 and 1.5%) of T*reculia african* seed gum as with other standard suspending agents including, sodium carboxymethylcellulose, guar gum and bentonite then evaluated using such parameters as, sedimentation profile, redispersibility, rheology and pH. Moisture content of the agents were obtained with *T. africana* gum (8.02%), guar gum (7.34%), sodium CMC (8.57%) and bentonite (5.11%). The hydration capacity obtained was sodium CMC (8.23%), *T. africana* gum (7.97%), guar gum (6.96%) and bentonite (7.34%) while swelling index as determined was *T. africana* gum (8.56), sodium CMC (8.30), guar gum (7.83) and bentonite (5.41). The pH of *T. africana* seed gum from analysis was in the range of 6.9 to 7.4. To evaluate the suspending properties of the gum, aceclofenac suspension was prepared in various batches of concentration range, 0.5 to 1.5% and each batch separately made into a flocculated and deflocculated system. The formulation (flocculated or deflocculated), was evaluated based on the sedimentation profile, redispersibility, rheology and pH of the product. Values of sedimentation obtained relative to 1.5%w/v concentration of the suspending agents, in the flocculated suspension after 5days was guar gum (0.78), *T. africana* gum (0.58), sodium CMC (0.56) and bentonite (0.39).**

Key words: ***T. africana*** **gum, suspending agents, aceclofenac, suspension, evaluation**

I. INTRODUCTION

Plant mucilages are important pharmaceutical polysaccharide with wide range of applications such as thickening, binding, disintegrating, emulsifying, stabilizing and gelling properties. They have also been used as matric,mes for sustained and controlled release drugs. These polymers often termed as natural gums and mucilages are biocompatible, cheap and easily available and are sometimes, preferred to semi synthetic and synthetic excipients because of their non- toxic, low cost, ready availability, emollient and non-irritant properties [1].

Gums are considered to be pathological products formed following injury to the plant or owing to unfavorable conditions, such as drought and breakdown of cell walls (extra cellular formation: gummosis) hence they readily dissolve in water. Mucilages on the other hand are general normal products of metabolism, formed within the cell wall of plants (intracellular formation) hence regarded as physiological products of plants which forms slimy masses in the presence of water [2].

Normally, when gums and mucilages come into contact with water there is an increase in viscosity due to their complex nature as they consists of monosaccharides, polysaccharides and other derivatives, hence after a long period of storage their viscosity reduces, and this may be due to a resultant effect of depolymerisation [3].

Aceclofenac: This is a non–steroidal anti-inflammatory (NSAID) agent with analgelsic, antipyretic and platelet inhibitory actions. They prevent the synthesis of prostaglandin by inhibiting cyclooxygenase, which converts arachidonic acid to cyclic endoperoxides, precursors of prostaglandin [4].

The drug, potently inhibits the cyclo-oxygenase enzyme (cox-2) that is involved in the synthesis of prostaglandins (inflammatory mediators) which causes pains, swellings, inflammation in osteoarthritis, rheumatoid arthritis, ankylosing spondylosis and fever. Aceclofenac is orally administered and belongs to BCS class II as it possesses poor aqueous solubility, displays high permeability hence easily penetrates into synovial joints in patients with osteo arthritis and related conditions [5]. It is also reported to be effective in other painful conditions involved in dental and gynecological conditions. In 1991, aceclofenac was developed as an analog of a commonly prescribed NSAID, via chemical modification in an effort to improve the gastro intestinal tolerability of the drug [6].

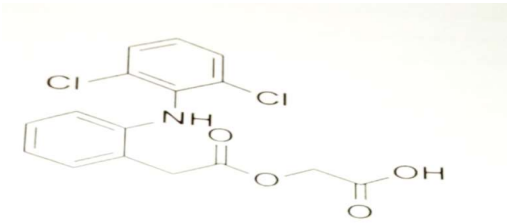

FIG1: Molecular structure of Aceclofenac (2-(-2-(2-.6di chloro anilino)phenyl)oxy acetic acid).

Chemical properties: The molecular formula is $C_{14}H_{13}Cl_2NO_4$, molecular weight 354.38, melting point 153^0C and is practically insoluble in aqueous medium.

Mechanisms of Action: Aceclofenac is an NSAID that inhibits both Isoforms of COX-enzymes involved in the inflammatory cascade. COX-1enzyme is a constituent enzyme involved in prostacyclin production and protective functions of gastric mucosa whereas COX-2 is an inducible enzyme involved in

the production of mediators in response to inflammatory stimuli. Aceclofenac displays more selectivity towards COX-2 than COX-1 thus promoting gastric tolerance compared to other NSAIDS. The aceclofenac in addition to causing the inhibition of prostaglandin (PGE2) synthesis, also inhibits the production of inflammatory cytokines, interleukins (IL-1b), and tumor necrosis factors(TNF). It also targets the synthesis of glycosaminoglycan and mediates chrondro protective effect [7].

Aceflofenac is rapidly and completely absorbed from the gastro intestinal tract and circulates mainly as an unchanged drug following oral administration. Peak plasma concentration is reached around 1 to 3hours post-ingestion and the drug penetrates into the synovial fluid where the concentration may reach up to 60% in the plasma.

The main route of elimination of aceclofenac is via urine as glucuronidated and hydroxylated form accounting for about 80% of clearance of the drugs while about 20% of the dose is excreted via feces [8].

Pharmaceutical Suspensions: A pharmaceutical suspension is a coarse dispersion in which insoluble solid particles are dispersed in a liquid medium and is thermodynamically unstable. This characteristics, makes it necessary to include in the formulation, a stabilizer or suspending agent which acts to reduce the rate of settling and permits easy redispersion of any settled particulate matter, the agents acts also by protective colloidal action as well as increasing consistency of the suspension medium [9].

Suspensions formulated is evaluated, considering the redispersibility of insoluble drug substance since this is pertinent in its formulation more so, as it is necessary that for a fairly uniform and accurate dose of the medicament to be dispensed, the contents must be homogenously mixed and remain both physically and chemically stable throughout the shelf life of the formulation.

The suspension formulation must be included with a suspending agent and such could consist of, inorganic materials, synthetic compounds, or polysaccharides (alginates, ethylcellulose, sodium carboxy methylcellulose, microcrystalline cellulose, acacia gum, bentonite, carageenan, gelatin etc). These materials besides acting as, a suspending agent imparts viscosity to the medium and form film around particle causing decreased inter-particulate attraction. They also act as thickening agents and increase viscosity of the solution hence preventing sedimentation of the suspended particles. A good suspension formulation should therefore be associated with thixotropic characteristics [10].

The selection of amount of suspending agent is dependent on the presence or absence of other ingredients which may have an ability to act as a suspending agent or which contributes to viscosity of the medium. The physical stability of a suspension should mainly dependent on the type of suspending agent rather than the physical characteristics of the drug.

Formulation of suspensions is often, influenced by such factors as particle size control and use wetting agents.

Particle size Control: It is necessary to ensure that the drug to be suspended is of acceptable particle size prior to the formulation as this will enhance slow rate of sedimentation. It is also worthy to note that particles greater than 5μm diameter, impart gritty texture to the product although this may be small when initially manufactured but on storage a degree of crystal growth might occur as a result of temperature fluctuations whereby the solubility of the drug may increase with temperature increase, but on cooling, it crystallizes. This behavior could be more peculiar with slightly soluble drugs example paracetamol.

Use of wetting agents: Some insoluble solids may, easily be wetted by water and dispersed readily throughout the aqueous phase with only minimal agitation. Most however exhibits varying degree of hydrophobicity and will not be easily wetted and such particles may form large porous clumps within the liquid, while others remain on the surface and become attached to the upper layer of the container. To ensure adequate wetting, the interfacial tension between the dispersed and continuous phases must be reduced so that the adsorbed air is displaced from the solid surfaces by the liquid hence intense shearing action need be applied during mixing [11].

Stability effect of suspensions is, characterized by such activities as flocculation and deflocculation systems.

In the *deflocculated systems*, the particles are not associated; pressure on the individual particles leads to their close packing at the bottom of the container to an extent that secondary energy barriers are overcome and become irreversibly bound together to form a cake. This is, usually prevented by inclusion of a flocculating agent in the formulation but not by reduction of particle size or increasing the viscosity of the continuous phase. Examples of deflocculates include sodium citrate and potassium hydroxide.

In flocculated systems however, repulsive barriers between particles is reduced and they form loosely bonded structures (*flocs*). The particles therefore settle as flocs and not as individual particles. Because of the random arrangement of the particles in the flocs, the sediment is not closely packed and caking does not readily occur although clearance of the supernatant becomes too rapid for an acceptable pharmaceutical formulation. Examples of flocculants include calcium hydroxide and gelatin [12].

Quality control of suspensions is assessed by such processes as:

Sedimentation volume: Redispersibility is the major consideration in assessing the acceptability of a suspension. The measurement of the sedimentation volume (ratio of the height of sediment to height of the initial suspension) and the

ease of redispersion, form two of the most common basic evaluative considerations and the larger the value of sedimentation volume, the better is the suspendability.

Particle Size distribution: The freeze-thaw cycling technique used for assessing suspension stability, result in increase of particle growth and may indicate future state after long storage. It is of importance to study the changes for absolute particle size and size distribution and this can be performed indirectly using optical microscopy or sedimentation technique using Andreasen or Coulter counter apparatus [13].

Stability testing: It is not often possible to conduct accelerated temperature studies for suspensions as could be done in solutions since suspensions exhibits thixotropic properties and a rise in temperature could alter its properties. Also in the physical form, the preparation might exhibit parameters that may not be extrapolated to those occurring in the normal system. Obtaining a valid temperature data could be of help in the estimation of physical stability of a product at normal storage conditions though extended aging tests, may be employed under various conditions to obtain the desired information.

The aim of the study is to assess the efficacy of gum from *Triculia africana* seeds as a polymer in aceclofenac suspension formulation in comparison with standard suspending agents such as, guar gum, sodium CMC and bentonite.

II. MATERIALS

All chemicals used were of analytical grade and includes: bentonite (BDH England), NaCMC (Griffin &Geogy, England), guar gum(May and Baker, England),Glycerol (Avery & Baker, England), Methyl paraben (May &Baker, England), Calcium hydroxide(May & Baker England), Sodium citrate(May & Baker),Propylene glycol (kermel, China), gum from *Treculia africana* seeds (Pharm Tech lab, University of Port Harcourt), aceclofenac powder BP (batch no: al Acf 007 1114, neutral code no ra/drugs/Raj-2399), bench centrifuge (Gallenkamp, England), oven (New Life Medical, England), muffle furnace (Sheffield, England), analytical balance (OHAUS, China), pycnometer, Brookfield viscometer (DV2T, Brookfield Engineering Laboratories, Massachusetts, USA).

III. METHOD

PHYSICOCHEMICAL CHARACTERIZATION OF SUSPENDING AGENTS

Solubility Test

The polymers were evaluated for solubility in water, ethanol and acetone.

A 1.0g quantity of the gum respectively was weighed and transferred into a clean test tube containing 10ml of solvents. Each of the mixture was shaken vigorously and observed for solubility or dispersibility of the agents.

Moisture Content

An empty crucible was weighed and the weight recorded. 1.0g of each of the sample was transferred to the crucible and weighed. The crucible was placed in an oven at 100^0C for 2hrs, until a constant weight was reached. The crucible was reweighed and the data recorded.

Hydration Capacity

The hydration (water retention) capacity of the respective powders was determined adopting the method as described. A 1.0g quantity of powder (y) was placed in a 15ml plastic centrifuge tube and 10ml of water was added. The tube was shaken intermittently over 2hr and left to stand for 30mins. This was centrifuged for 10mins at 3000rpm. The supernatant was decanted and the weight of the powder after water uptake and centrifugation (x) was determined. Triplicate determinations were carried out and mean values obtained.

$$\text{Hydration capacity} = x * \frac{100}{Y} \quad \text{-------- (1)}$$

Where y = weight of dry powder

X = weight of moist powder after centrifugation.

Swelling Index

The swelling index was determined using the method of Ohwoavworhua and Adelakun (14). The tapped volume occupied by 1g of the powder (V_1), was noted. The powder was then dispersed in 5ml of water and the volume made up to 10ml with water. After 24hr of standing, the volume of sediment (V_0) was determined and in triplicate. The swelling capacity was computed as follows:

$$\text{Swelling capacity} = \frac{V_1}{V_0} \quad \text{------- (2)}$$

p^H of Samples

The pH of 1.0% w/v dispersion of the suspending agents as well as the active pharmaceutical ingredient (API) was determined in triplicates using the pH meter (Helmreasinn, PHS-25).

Table 1: Preparation of Aceclofenac Suspension

Materials	Batch 1	Batch 2	Batch 3	Control
Aceclofenac (g)	2.0	2.0	2.0	2.0
Propylene glycol (ml)	10	10	10	10
Glycerol (ml)	0.8	0.8	0.8	0.8
Polymer (g)	0.5	1.0	1.5	-
Methylparaben (g)	0.1	0.1	0.1	0.1
Water (ml) qs	100	100	100	100

Polymers: *T. africana* gum, guar gum, sodium CMC, bentonite

A 2.0g quantity of aceclofenac powder was weighed and transferred into a porcelain mortar. 10ml of propylene glycol

and 0.8ml of glycerol was added and triturated to dissolve the powder. A 0.1% w/v of methyl paraben and hydrated suspending agent were added and mixed. The mixture was made pourable using distilled water then transferred into a suitable calibrated container and the content made up to the required volume, stoppered, shaken vigorously, and allowed to settle. The procedure was repeated for the preparation using different concentrations of the suspending agents as 0.5% w/v, 1.0% w/v and 1.5% w/v of *Treculia africana* gum, guar gum, bentonite and sodium CMC and in triplicates.

Selected batch from each of the prepared suspensions was deflocculated to determine the degree of flocculation using sodium citrate (1g), while flocculated suspensions were made using calcium hydroxide (1g).

IV. EVALUATION OF ACECLOFENAC SUSPENSION

Sedimentation Volume

The initial volume, V_o was recorded for each batch of aceclofenac suspension immediately after preparation. The sedimentation volume, V_t at any given period was also recorded on daily basis for six days. Percentage sedimentation volume (*F)* was calculated as:

$F = [V_t/V_o] \times 100 \ldots\ldots\ldots\ldots\ldots (3)$

Rheology (Flow Rate)

The time required for 10ml of each batch of aceclofenac suspension to flow through a 10ml glass pipette of orifice diameter 1.0mm was determined and the flow rate (mls^{-1}) calculated.

Flow rate (F_R) = Volume of pipette (ml) / Flow time (sec)……(4)

Viscosity Mesurement

The viscosity of each batch of aceclofenac suspension was determined using a Brookfield viscometer involving the of use spindle #2 at 12rpm for 30sec at 27.4^0C and determinations carried out in triplicates .

Redispersibility Tests

After 25th day of the storage, the respective container of each batch of the preparation was, shaken in an upward and downward direction. The number of shakes for the sediments to re-disperse and produce a homogenously suspension was noted.

P^H of Suspension

The pH of 1.0%w/v of each batch of the suspension was determined using Helmreasinn pH meter (PH-25) and at durations of 0-21days.

Degree of Flocculation

The degree of flocculation was determined using the equation as given by Kumar et al 2009 [15].

V. RESULTS

Table 2: Physicochemical characterization of the gums

Test	*Treculiaafricana*	Guar gum	Sodium CMC	Bentonite
Solubility Test Ethanol	Non-dispersible	Non-dispersible	Non-dispersible	Non-dispersible
Acetone	Non-dispersible	Non-dispersible	Non-dispersible	Non-dispersible
Water	Non-dispersible	Non-dispersible	Insoluble	Non-dispersible
Moisture content (%)	8.02±0.02	7.34±0.02	8.57±0.01	5.11±0.03
Hydration capacity (%)	7.97±0.01	6.96±0.03	8.23±0.02	5.01±0.04
Swelling index (in distilled water)	8.56± 0.03	7.83±0.04	8.30±0.15	5.41 ± 0.05

All values, expressed as the mean of triplicate values ± standard deviation

Table 3: pH of various concentrations (% w/v) of suspending agents

Concentration (%)	Mean triplicate pH determinations			
	Treculia africana	Guar gum	Sodium CMC	Bentonite
0.1	7.0	10.0	7.5	8.3
0.2	7.1	10.2	7.6	8.4
0.5	7.2	10.3	7.8	8.6
1.0	7.4	10.5	8.0	88

Table 4: Flow rate and viscosity of suspension (Flocculated)

Suspending agent	Concentration (% w/v)	Flow rate (ml/sec)	Viscosity (cp)
T. africana gum	0.5	1.8 ± 0.02	8.0 ± 0.03
	1.0	1.3 ± 0.03	25.0 ± 0.02
	1.5	1.0 ± 0.01	32.0 ± 0.01
Guar gum	0.5	1.5 ± 0.01	9.0 ± 0.01
	1.0	1.0 ± 0.02	31.0 ± 0.12
	1.5	0.8 ± 0.02	49.0 ± 0.01
Sodium CMC	0.5	1.7 ± 0.01	8.0 ± 0.10
	1.0	1.2 ± 0.03	31.0 ± 0.2
	1.5	1.0 ± 0.01	34.0 ± 0.02
Bentonitc	0.5	1.6 ± 0.02	9.0 ± 0.01
	1.0	1.5 ± 0.03	29.0 ± 0.01
	1.5	1.4 ± 0.01	39.0 ± 0.02

Table 5: Flow rate and Viscosity of Suspension (Deflocculated)

Suspending agent	Concentration (% w/v)	Flow rate (ml/sec)	Viscosity (c poise)
T. africana gum	0.5	1.5 ± 0.02	20.0 ± 0.02
	1.0	0.9 ± 0.03	34.0 ± 0.01
	1.5	0.6 ± 0.02	49.0 ± 0.02
Guar gum	0.5	1.3 ± 0.02	22.0 ± 0.01
	1.0	0.6 ± 0.01	43.0 ± 0.02
	1.5	0.3 ± 0.02	75.0 ± 0.02
Sodium CMC	0.5	1.5 ± 0.01	20.0 ± 0.01
	1.0	0.8 ± 0.03	36.0 ± 0.01
	1.5	0.5 ± 0.01	47.0 ± 0.02
Bentonite	0.5	1.1 ± 0.02	21.0 ± 0.02
	1.0	0.7 ± 0.03	35.0 ± 0.02
	1.5	0.4 ± 0.01	51.0 ± 0.02

All values, expressed as the mean of triplicate values ± standard deviation.

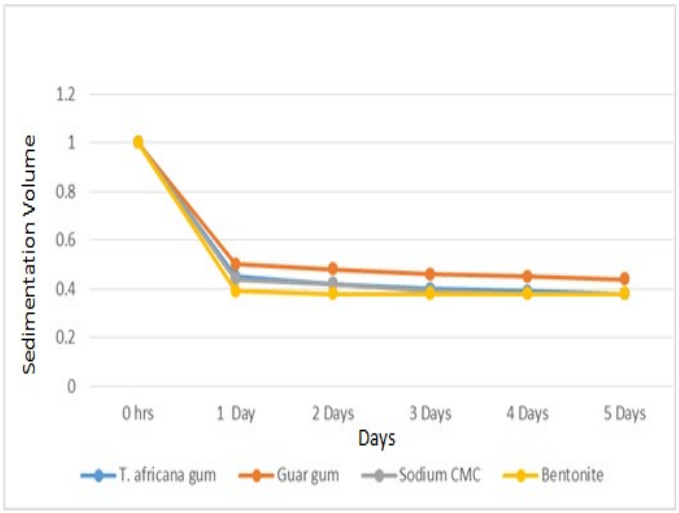

Fig 2: Sedimentation of flocculated suspensions made with 0.5%w/v concentration of different suspending agents.

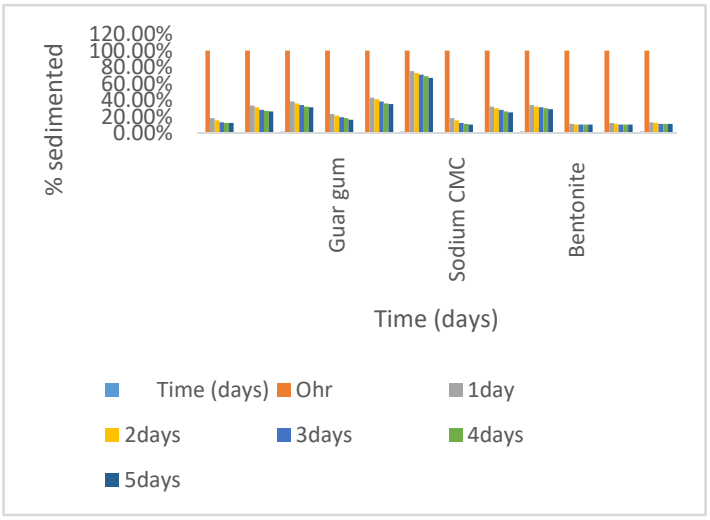

Fig5: Plot of % Sedimentation volume against time (days) in deflocculated suspension

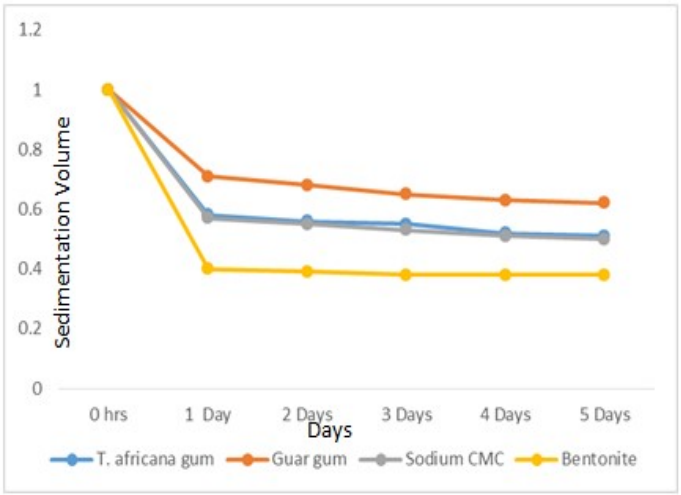

Fig 3: Sedimentation volume of flocculated suspensions with 1.0% w/v of polymers.

Fig 6: Redispersibility of flocculated suspension with 0.5%w/v of polymers

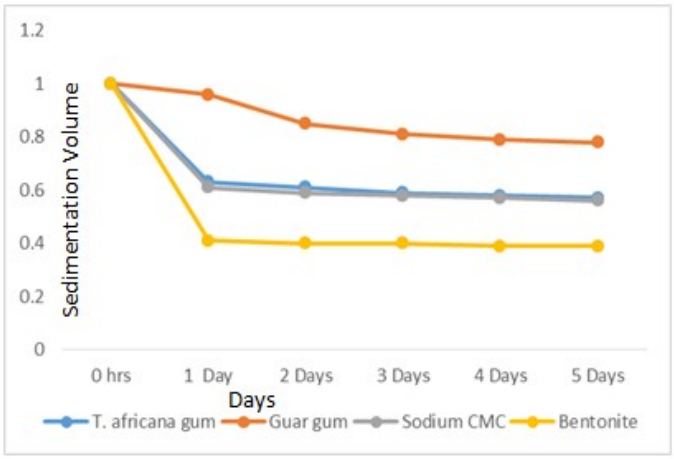

Fig 4: Sedimentation volume of flocculated suspensions with 1.5%w/v of suspending agents.

Fig 7: Redispersibility of flocculated suspension with 1.0% w/v polymers

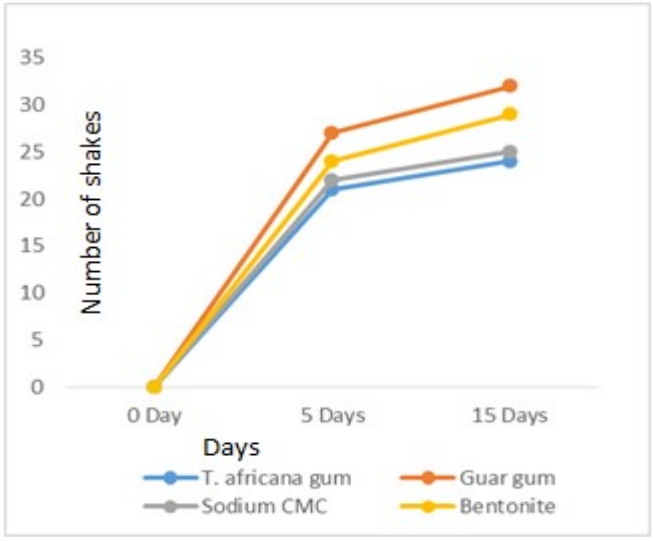

Fig 8: Redispersibility of flocculated suspension with 1.5% w/v of polymers

Table 6: Redispersibility for the deflocculated suspension

Suspending agent	Concentration (% w/v)	Rate of redispersibility (cycles)		
		5 days	15 days	25 days
T. africana gum	0.5	31	36	42
	1.0	54	60	65
	1.5	68	73	79
Guar gum	0.5	45	49	56
	1.0	65	71	77
	1.5	83	89	96
Sodium CMC	0.5	29	35	41
	1.0	51	57	66
	1.5	65	72	79
Bentonite	0.5	39	46	52
	1.0	57	62	69
	1.5	71	77	83

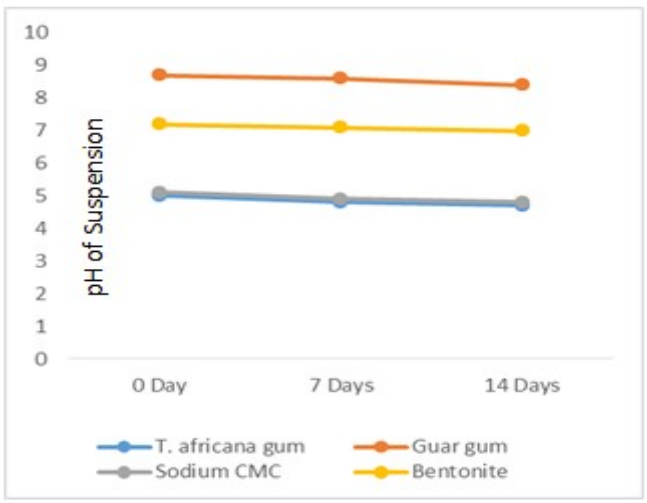

Fig9: pH profile of flocculated suspension with 1.5%w/v of polymers

Table7: Redispersibility for the deflocculated suspension

Concentration (% w/v)	Degree of flocculation at the end of 5 days)			
	T. Africana gum	Guar gum	Sodium CMC	Bentonite
0.5	2.86	2.95	2.80	1.80
1.0	1.96	1.77	2.00	1.80
1.5	1.87	1.96	1.83	1.54

VI. DISCUSSION

The new plant gum obtained from *Treculia africana seed* was subjected to preliminary physicochemical characterization then compared with standard polymers and suspending agents like guar gum, sodium CMC and bentonite and the results summarized as in table 2.

The *T.africana seed* gum was found to be non-dispersible in ethanol, acetone and water, along with guar gum and bentonite but sodium CMC although non- dispersible in ethanol and acetone is dispersible in water.

Moisture content of the suspending agents was observed in the order: sodium CMC (8.57%) > *T. africana* gum (8.02%) > guar gum (7.34%) > bentonite (5.11%). Similarly, the order of hydration capacity was found as sodium CMC (8.23%) > *T. africana* gum (7.97%) > guar gum (6.96%) > bentonite (7.34%) while that of swelling index as determined was in the order, *T. africana* gum (8.56) > sodium CMC (8.30) > guar gum (7.83) > bentonite (5.41). These results depicts appreciable water retention and absorption characteristics of the extracted *T. africana gum* comparable to that of NaCMC revealing the gum as a natural polymer which could appear superior to guar gum and bentonite upon application as excipients in foods, pharmaceutical and dairy products, as suspending or probable binding agents if considered, especially in solid dosage formulations.

Knowledge of the pH of an excipient is an important parameter and determines its suitability in formulations since the stability and physiological activity of most preparations depends on pH. From the result obtained, the pH of *T. africana* seed gum increased gradually with increased concentration and value obtained ranged between 6.9 to 7.4, and this indicates the gum to be a neutral and non- toxic polymer hence could be suitable for the human physiological system and any formulation for such purpose.

To evaluate the suspending properties of these agents, an aceclofenac suspension was formulated in different batches containing the suspending agents; *T. africana* gum, guar gum, sodium CMC and bentonite in the concentration range of 0.5 to 1.5%, and for each batch, a flocculated and deflocculated suspension system was made. The formulations were evaluated based on their sedimentation profile, redispersibility, rheology and pH.

Considering the sedimentation profiles, observed flocs in flocculated systems tend to fall together producing a distinct boundary between the sediment and the supernatant liquid.

The liquid above the sediment is clear because even the small particles present in the system was associated as flocs.

The deflocculated suspension, had range of particle sizes which in accordance with Stoke's law, the larger particles settles more rapidly than the smaller particles and thereby had no clear boundary distinction, while the supernatant remained turbid for considerably longer period.

From the results obtained in fig 2, 3 & 4, the sedimentation volume of the suspension increased with increasing concentrations of the suspending agents in both flocculated and deflocculated suspensions. The order of sedimentation rate in 1.5% concentration of the suspending agent in the flocculated suspension after 5days was guar gum (0.78) > *T. africana* gum (0.58) > sodium CMC (0.56) > bentonite (0.39).

According to Martins et al, if the sedimentation volume is not less than or greater than I then the sedimentation volume becomes equal to the suspension and is said to be in flocculation equilibrium (meaning that the ultimate volume is equal to the sedimentation volume).

However, the sedimentation volume gives only a quantitative account of flocculation because it lacks a meaningful reference point. A more useful parameter for flocculation is β, known as the degree of flocculation, which is the ratio of ultimate sedimentation volume in the flocculated and deflocculated system. It is therefore, considered a more fundamental parameter than the sedimentation volume because it relates the volume of the flocculated sediment to that of a deflocculated system.

The β was seen to increase with increase in concentration of suspending agent. The order observed in 1.5%w/v of the suspending agents was guar gum (1.96) > *T. africana* (1.87) > sodium CMC (1.83) > bentonite (1.54).

Viscosity (a measure of resistance to motion) of the flocculated system was, observed to be greater than that of the deflocculated system and it tends to increase with increasing concentration of the suspending agents. The order of viscosity considering 1.5%w/v of the suspending agent was, guar gum (49cP) > bentonite (39cP) > sodium CMC (34cP) > *T. africana* gum (31cP). The rheological studies of the suspension formulated as seen in table 5 and 6 shows that the viscosity of each suspension was directly proportional to the concentration of the suspending agents but to varying degrees depending on the type of suspending agent used.

The differences in viscosities had implication on many parameters including flowability and sedimentation volume, such that an increase in the viscosity ultimately lead to a decrease in the flow rate of the suspension, but invariably leads to an increase in sedimentation volume of sediments.

Similarly, from the batch of flocculated suspension, the flow rate decreased with increased concentration of the suspending agent and the order of flow rate in 0.5%w/v content of the suspending agent as observed is, *T. africana* gum (1.8ml/sec) > Sodium CMC (1.7ml/sec) > bentonite (1.6ml/sec) > guar gum (1.5ml/sec).

The flow rate of the flocculated suspension was less than that of the deflocculated suspension. This is because the formation of aggregates/floc in the flocculated system along with associated water molecules helps to increase hydrogen bonding and hence intermolecular attraction and this contributes to an increase in viscosity and ultimately leading to prolonged time of flow. On the other hand, in a deflocculated suspension, flocs do not form and each particle exists individually on its own entity and therefore, the viscosity is not influenced to a high extent as compared to the flocculated system.

Since suspension produce sediments on storage, they must be readily redispersible to ensure the uniformity of dose. If the sediment remains even after shaking vigorously for a specified time, the system is described as caked. The redispersibility (in cycles) was carried out at intervals of 5, 15 and 25 days for the flocculated and deflocculated suspensions as seen on table 6, and the redispersibility was observed to increase as the storage time increased and with increase in concentration of the suspending agent especially with the flocculated system.

The order of redispersibility as in number of shakes for 0.5%w/v of the suspending agents in the flocculated suspension after 5 days was guar gum (21) > bentonite (19) > sodium CMC (17) > *T. africana* (16). This indicates that the suspension made with *T. africana* gum took the least effort to redisperse hence could be more acceptable as a suspending agent than guar gum which took more energy to redisperse.

The number of redispersibility cycle in flocculated system is faster than that of deflocculated system. This is because the loose structure of the rapidly sedimenting flocs tends to be preserved in the sediment while therefore containing appreciable amount of liquid which provides weak hydrogen and Vander Waals force of attraction and this cause the volume of the sediment to be relatively large resulting in the sediment which became easily redipersed by agitation.

However, in a deflocculated system, the repulsive force between individual particles, allow the particles to slip past each other. This property together with the slow rate of sedimentation prevents the entrapment of moisture, and allows the formation of compact sediment often referred to as cake and this activity makes it to be usually difficult to redisperse by agitation.

VII. CONCLUSION

The suspension prepared with *T. Africana* seed gum from the results obtained seems to have appreciable, sedimentation profile, redispersibility, viscosity and flow rates relatively comparable to that of NaCMC, but seems better considering these parameters, when compared with that prepared using guar gum and bentonite.

Natural gums in recent time are, being identified as, promising biodegradable polymeric materials with clear advantages over synthetic polymers. However, there is need to harness and develop other newer sources and as well, modify existing ones for the formulation of novel drug, biotechnological application and other delivery system.

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