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POLYELECTROLYTE COMPLEXES OF *IRVINGIA GABONENSIS* GUM AND GELATIN: PERFORMANCE OF SUSPENDED CHALK PARTICLES

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ABSTRACT

The suspending properties of the polyelectrolyte complexes (PECs) or co-precipitates from Ogbono gum, (*Irvingia gabonensis,* variety excels, Fam. Irvingiaceae) and gelatin were carried out. The gum was extracted, co-precipitated with gelatin and used to prepare chalk suspension. Parameters determined were as follows: sedimentation rate, viscosity, pH, redispersibility number and effect of electrolytes on the rheology of the suspension. The result was compared with that of a commercial brand of Mist Magnesium trisilicate (Product X) obtained from Gloria, G Pharmaceuticals, Nigeria Limited. The results of the study credited *Irvingia gabonensis* gum as being a better suspending agent alone than gelatin. In furtherance, the PECs-containing suspension prepared with 1:4 combination of gelatin and *Irvingia gabonensis* gum had the best properties in relation to the assessed parameters as being the best viscosity impacting agent with the least redispersibility number which is a marker to its suspension not forming cake upon storage as well as making for easy re-suspension of sedimented particles and ensuring accurate dosing superior to the Product X.

Keywords: *Polyelectrolyte complexes; Irvingia gabonensis; Gelatin; Chalk; Suspension.*

INTRODUCTION

Irvingia gabonensis (Bobo (Sierra Leone), Boboru, Wanini (Ivory Coast), Andok (Cameroon), Meba, Mueba (Zaire), Oro, Oba (Nigeria) is an economic fruit tree native to tropical countries of central and West Africa[1, 2]. The fruit of *Irvingia gabonensis* has a sweet mesocarp and is eaten fresh. It is otherwise referred to as wild mango or dika nut. The edible kernel is used for culinary purposes and is traded widely[3-5].

Further search of the literature revealed some studies on the genetic make and diversity of the plant in terms of tree to tree variation[6-8] and intra-specific distribution of genetic variation to produce appropriate conservation and sustainable utilization strategies[1, 9, 10]. However, *Irvingia gabonensis* has been credited as decreasing body weight (obesity) and total cholesterole, LDL-cholesterole, triglycerides and an increase in HDL-cholesterole in Cameroon[11]. It has also found use in the pharmaceutical industry as dika fat/wax[5, 12]. It is locally called Ogbono and is used to make dika fat in Gabon. The soup thickening potential is as a result of the gum, a polymeric hydrophilic colloidal material with thickening and gelling properties. The aim of the present study is to investigate the suspending properties of the gum alone and as a PEC or co-precipitate of gelatin in the suspensions of Calcium carbonate (chalk) particles.

An increasing number of articles on PECs reflect the growing scientific and industrial interest in this field. PECs are complexes of cationic and anionic polyelectrolytes. In its most simple form complex formation is observed when the two oppositely charged species-polyelectrolyte and polyelectrolyte are mixed in aqueous solution. The mixing of solutions of polyanions and polycations leads to the spontaneous formation of interpolymer complexes under release of the counterions. The driving force of complex formation is mainly the gain in entropy due to the liberation of the low molecular counterions. However, other interactions such as the bonding type may play an additional part. From the energetic point of view, PEC formation may even be an endothermic process, because of the elastic energy contributions of the polyelectrolyte chains, impeding the necessary conformational adaptations of the polymer chains during their transition to the much more compact PEC structures. PEC formation leads to quite different structures, depending on the characteristics of the components used and the external conditions of the reaction.

A suspension will usually provide more rapid dispersion and dissolution of the drug than either tablets or capsules, provided the drug particles are optimum, easily redispersible and do not settle excessively or cake on storage. It therefore requires that the drug should be finely powdered and mixed with the suitable suspending agent, which can be natural, semi-synthetic or synthetic. Suspensions can be prepared either by dispersion or precipitation. The current work aims at achieving an improved suspendability of Chalk particles by the use of PECs of gelatin and *Irvingia gabonensis* gum as a PEC.

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EXPERIMENTAL

Materials

The following materials were procured without further purification: acetone, benzoic acid (BDH, England), gelatin (type B) (Sigma Chemica Co.), chalk powder (Board master) and Mist Magnesium trisilicate (Gloria, G Pharmaceuticals, Nigeria Limited). Distilled water was from an all glass still. All other reagents were of analytical grades and were used as such.

Extraction of *Irvingia gabonensis*

Some 400 g of *Irvingia gabonensis* seeds were bought from a local market in Nsukka, Enugu State, Nigeria. The extraction was done following an earlier described method[13] only with a little modification. Briefly, the edible flesh covering the seeds was removed to expose the hard cortex of the seeds. This cortex of the *I. gabonensis* seeds were carefully cut open with the aid of a sterile blade to expose the hard milky cotyledons which were dried at 60 ^{o}C in an oven (Model OV110, Gallenkamp, Germany) for 3 h. The dried cotyledons were pulverized in a hammer mill and passed through a sieve of mesh size of 0.3 mm. The resulting cream coloured powder was sticky and had a pleasant odour.

300 g of this powder was dispersed in distilled water, homogenized and left to stand for 24 h. The mucilage formed was then expressed through a muslin cloth and the insoluble debris discarded. The resultant filtrate was then desolvated with acetone. This product of desolvation (*Irvingia gabonensis* gum) was dried in a hot air oven and then pulverized. This powder was employed in the suspension technology.

Formulation of PECs or Co-precipitates

Co-precipitation of gelatin and the gum was done using acetone. Different ratio combinations of 1:1, 1:2, 1:3, 1:4, 1:0 and 0:1 respectively of the gelatin and gum were used. Briefly, the accurate quantities of gelatin were dissolved in warm water and further mixed with the gum. This was then precipitated using acetone and the precipitate desiccated for 72 h, ground and used for preparing chalk suspension.

Formulation of chalk suspension

The appropriate quantities of the ingredients (chalk, 100 mg; benzoic acid, 0.05 %; PECs, gum or gelatin, 2 % and distilled water to 50 ml) were weighed/measured out separately. The chalk powder was put in the mortar and triturated for about 2 min with an aliquot of benzoic acid. The PECs or co-precipitates were each time dissolved in warm water separately, later mixed together and used to triturate the chalk particles. The mixture was made pourable into the suspension bottles and the mortar rinsing were added to the bottle, made up to 50 ml and polished.

Sedimentation volume measurement

50 ml volume each of the suspension was put into a calibrated measuring cylinder and left undisturbed. At intervals, the volumes of the sediments were taken and the sedimentation volume calculated according to the relationship $F = H_t/H_o$; where H_t is the equilibrium volume of sediment and H_0 is the original volume of the suspension.

Effect of electrolytes on suspension stability

Different concentrations of the electrolytes (1 % w/v, 2 % w/v each of NaCl and $CaCl_2$) were prepared. This was later added to 40 ml of the suspension prepared with 1:3 PECs of gelatin and *I. gabonensis* gum to make a total volume of 50 ml. The sedimentation volume was determined daily for one-week.

Suspension rheology

The viscosity of about 50 ml of each suspension batch was determined using the viscometer (Haake Rotovisco Model RVI, NJ 07662) using concentric cylinder assembly. The viscosity was determined at different shear rates designated by the fixed speeds of the viscometer. The viscosity was plotted against the concentrations of the PECs to assess the effect of concentration on the viscosity of the suspensions. This determination was at 30 ^{o}C and triplicate determination was done in each case.

Suspension pH

Some 50 ml volume of suspension was poured into a beaker and the pH determined using a pH meter (Model 290 MK, Pye Unicam). Triplicate readings were taken and the procedure repeated for other batches.

Redispersibility number

After four weeks of storage of the entire suspension batches, the redispersibility pattern was evaluated. This corresponded to the number of times the measuring cylinder was manually inverted before the base of the cylinder became free of sediments.

Evaluation of the commercial brand, Product X

Product X was checked for pH, viscosity, redispersibility number and sedimentation volume. The results were compared with those of the test suspensions.

Statistical analysis

Triplicate determinations of each parameter were done and mean, SEM and S.D. were used to analyze them.

RESULTS AND DISCUSSION

The results emanating from this study shows that the volume of sediment consistently decreased on storage (Fig 1). The least volume of sediment was obtained in the formulation stabilized with gelatin alone. This dispersion had an initial sedimentation volume of 28 ml and exhibited the fastest rate of sedimentation that at 7 days, the final volume of sediment had gone down to 12 ml far less than the initial volume of sediment. This shows a great probability of the dispersion to form cakes which may lead to inaccurate dosing of the chalk

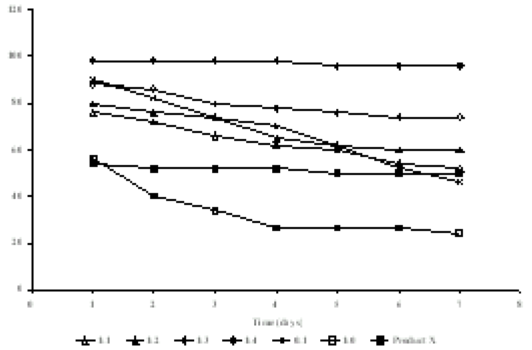

Fig. 1: *Sedimentation volume of chalk suspensions prepared using gelatin and I. gabonesis gum*

particles. The suspension prepared with *I. gabonensis* alone recorded an initial sedimentation volume of 43 ml while the final volume of sediment at 7 days was 23 ml. This shows that the *I. gabonensis* gum was a better suspending agent than gelatin since the volume of sediment was higher than that of gelatin after the storage period. It follows that the dispersion settled in somewhat wooly pattern that discouraged cake formation. However, the volume of sediment seen in the suspensions prepared with the PECs of gelatin and *I. gabonensis* gum concentration-dependently increased according to the quantity of *I. gabonensis* in the complex. For instance, the 1:4 PEC of gelatin and *I. gabonensis* showed an initial sedimentation volume of 49 ml while upon storage for 7 days, it had a final sedimentation volume of 48 ml. This shows that this ratio of PEC can very conveniently suspend the chalk particles for a relatively long period to ensure accurate dosage of the chalk. It also shows that this dispersion cannot form cakes since the sediment was more of wooly agglomerate which entrapped some water in-between to cause easy disentanglement and re-suspension of the chalk particles. The 1:3 PEC-containing suspension recorded an initial sedimentation volume of 44 ml while its final sedimentation volume at 7 days was 37 ml; that of 1:2 initially gave a volume of sediment at 40 ml while on storage for 7 days, the sedimentation volume became 30 ml. The 1:1 PEC-containing suspension had an initial sedimentation volume of 38 ml while its final sedimentation volume was 26 ml. It follows deductively that the PECs increased the suspendability of the chalk particles due to greater entanglement in their combination of *I. gabonensis* leading to rheological synergism (viscosity enhancers). As a result, the 1:4 PEC of gelatin and *I.gabonensis* was the best viscosity enhancer that indefinitely suspended the chalk particles followed by the 1:3 PEC. This is actually in accordance with stokes equation as earlier reported[14]. The *I. gabonensis* gum alone was a good suspending agent but upon storage formed smaller sediment than the 1:2 and 1:1 PECs-containing suspensions. This invariably means that PECs behaved better than the gum alone considering the final sedimentation volume which is an indicator to cake formation.

Electrolytes affect suspensions according to their valency which characterizes their precipitation power. It has been observed that in the absence of a salt, suspensions remained deflocculated and changed to flocculated system on addition of a salt[15]. The rate of settling depended on the valency of the electrolytes irrespective of concentration. This agreed with an earlier work[15] that aggregation efficiency increases with concentration and valency of ion (Fig. 2).

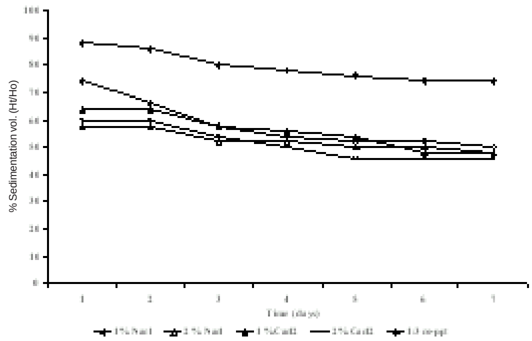

Fig. 2: *Effect of electrolyte on the sedimentation volume of 1:3 co-precipitate chalk suspension.*

The chalk suspensions had different viscosity readings. The suspension containing gelatin alone had the highest viscosity of 294 mPa.s while that containing *Invirgia gabonensis* gum alone gave the viscosity of 278 mPa.s (Fig 3). When the PECs were employed in formulating the suspensions, the viscosity and elasticity proportionally varied with the ratio combinations of the *Irvingia gabonensis* gum. Such that the 1:4 PEC of gelatin and *Irvingia gabonensis* gum had the highest viscosity of 275 mPa.s (amongst the PECs) and the 1:3 PEC gave a viscosity of 255 mPa.s. It was surprising to observe that the 1:1 PEC gave a viscosity reading of 270 mPa.s above that of 1:3 as well as 1:2 which also gave a reading of 265 mPa.s above that of 1:3. It is imperative therefore to state that the 1:3 PEC of gelatin and *I. gabonensis* gum had the least viscosity in all even though the differences in viscosity readings were generally not significant ($p<0.05$). Product X had a viscosity reading of 290 mPa.s lower than that of gelatin alone but higher than the gum alone as well as the PECs.

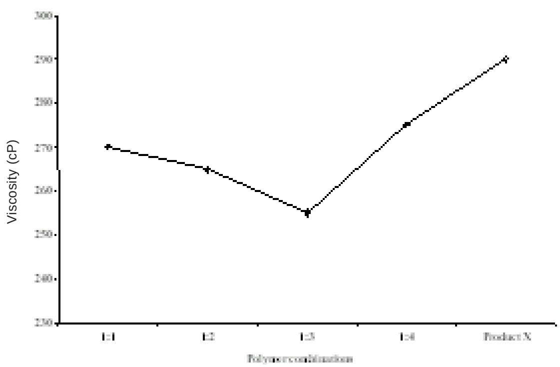

Fig. 3: *Effect of viscosity on the chalk suspension*

Product X had the highest pH reading of 8.50. The test results indicated the *Irvingia gabonensis* gum suspension batch to be weakly acidic (4.70) as well as gelatin alone (5.83) and the PECs-containing suspensions ($p<0.05$) (Fig. 4). This was actually expected because hydrocolloidal dispersions are generally acidic in nature[15-17]. Generally, co-precipitation produces a mass with increased molecular weight and higher degree of cross-linking which favours rheological synergism. According to an earlier observation[16], synergism of polymers occurs when polymers are combined. By implication, the interaction between the ordered region of the *Irvingia gabonensis* gum and unsubstituted "smooth" region of the glycoprotein resulted in synergism.

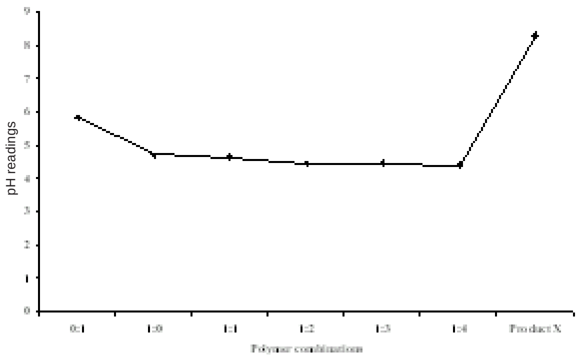

Fig. 4: *Effect of pH on the chalk suspensions*

The redispersibility number is an index of cake formation and the higher the redispersibility number the more the possibility of cake formation upon extended period of storage. Product X had a redispersibility number of 4 while the suspension formulated with gelatin alone had the redispersibility number of 6 (Fig. 5). This implies a greater propensity to cake formation in the gelatin-containing suspension. However, the suspension containing *I. gabonensis* gum alone had a redispersibility number of 3 together with all the suspensions prepared with PECs of 1:1, 1:2 and 1:3 whereas the 1:4 PEC-containing suspension had the redispersibility number of 2. This correlates the result of the sedimentation volume since the highest level of sediment was seen in the 1:4 PEC-containing

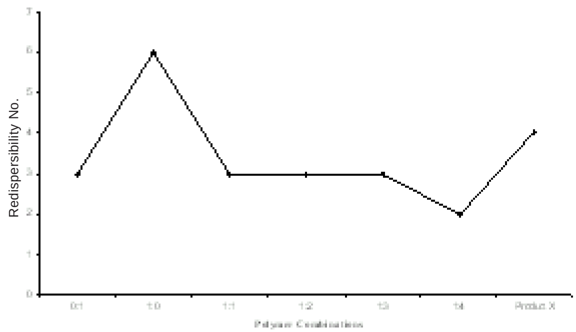

Fig. 5: *Redispersibility number of Chalk Suspensions prepared with gelatin and gabonensis gum*

suspension, it means that it would take little or no shaking to mix the content of the bottle before dosing. While the gelatin-containing suspension which had the least sediment upon storage will require more shaking to redisperse the sedimented suspension particles in order to ensure accurate dosing.

CONCLUSION

Irvingia gabonensis gum was found to have better suspending properties alone than gelatin. The suspension containing the *I. gabonensis* gum alone most comparatively equalled the use of the PECs of 1:1 of gelatin and the gum. It is imperative to say that since the PECs-containing suspensions (1:2, 1:3 and 1:4) had better properties in terms of the assessed parameters, that the use of *I. gabonensis* gum alone for suspension would therefore not make sense. However, the interaction existing between the two excipients in the form of PEC modified the properties of the individual entities crediting the 1:4 PEC of gelatin and *I. gabonensis* gum as the best excipient for suspension technology in all. This is because of the enhanced results obtained with this combination as the best viscosity enhancer around which all other properties like good redispersibility number (good stability against cake formation) and pH (weak acidity which will discourage microbial growth) revolved. This is actually in agreement with the literature that PEC can have rheological synergism and as a matter of fact, this PEC of 1:4 is the optimum concentration for use in suspension of chalk particles. Since the excipients are affordable, available and the method of preparation is simple, it follows that the use of the PEC at the optimum concentration of 1:4 of gelatin and *I. gabonensis* should be encouraged and explored to deliver drugs via other formulation approaches.

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