Emulsifying Properties of *Raffia hookeri* Gum and Its Blends with Tween 80 in Pharmaceutical Liquid Paraffin Emulsion

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Abstract: Researches have shown that *Raphia hookeri* gum could be used as a binder in pharmaceutical formulations and gums in general have been used as emulsifiers in liquid paraffin emulsion but nothing has been heard of *Raphia hookeri* in liquid paraffin emulsion as an emulsifier. This work was aimed at evaluating the emulsifying properties of Raphia gum in liquid paraffin emulsion. Two separate preparations containing different concentrations (1, 2, 3, 5 and 10% w/v) of Raphia gum and acacia gum respectively were prepared. Five liquid paraffin emulsions (200 mL each) were also prepared using 60 mL liquid paraffin as the oil phase and 6 g of the various combinations of Raphia gum and Tween 80 as emulsifier blend at ratio 1:5, 1:2, 1:1, 2:1 and 5:1. The preparations were assessed using density, viscosity and stability after 5 days of storage as evaluation parameters. By increasing the concentration of Raphia and Acacia gum, the density of emulsion formed increased. The ranking of the density was 10% > 5% > 3% > 2% > 1%. The viscosity of emulsion increased as the concentration of the gum increased. The viscosity which plays a role in the stability of emulsion increased as the concentration of gum increased. The ranking of viscosity was 10% > 5% > 3% > 2% > 1%. The stability of the emulsion was measured by the level of creaming and cracking. Emulsion containing 2% w/v of Raphia gum with a creaming index of 23% was more stable compared to the emulsion containing 3% w/v acacia gum with creaming index of 29.9%. The viscosity and stability of emulsion containing emulsifier blends of Raphia and Tween 80 increased with increase in the concentration of Raphia gum. Emulsion containing 3% w/v Raphia gum with no creaming was more stable than emulsion containing 1% w/v emulsifier blend. Raphia gum is suitable for use at a concentration of 2% w/v as an emulsifier in 50 mL of liquid paraffin emulsion competing alternatively to standard acacia gum for emulsification as against *Afzelia africana* in our previous research which was suitable for use at a concentration of 3% w/v as an emulsifier in 30% v/v liquid paraffin emulsion.

Key words: *Raphia hookeri* gum, emulsifying blends, liquid paraffin, emulsifying properties, density, viscosity, creaming.

1. Introduction

Liquid preparations have advantages such as ease of administration, faster absorption rate and flexibility of dosage forms. Some drugs cause lesser irritation when given as liquid preparation e.g. drugs like aspirin will cause irritation of the gastric mucosa when given as oral solid dosage forms but irritation is lesser. Even though liquid preparations have advantages, disadvantages also occur: measurement of the correct dosage is not easy, liquid preparation can be lost easily due to breakage of its container which is mostly glass, good media for micro-organism growth and less stable than solid preparations.

Liquid paraffin is an emulsion that is mostly used as a laxative. It works by mixing with and coating the intestinal contents, preventing colonic reabsorption of fecal water and increasing water retention in the stool leading to the formation of soft stool. It is to be used by adults and not for children under 2 years old. It is contraindicated in appendicitis, intestinal obstruction and fecal impaction. It is not advisable to be used by pregnant women but in cases where the benefit outweighs the risk it can be used. It has side effects such as diarrhea, stomach pain, nausea and vomiting, itching and skin rash. In the pharmaceutical and allied
industry, liquids can be prepared for two broad categories, including internal and external uses.

Emulsion is a preparation consisting of small globules of liquid (dispersed phase) distributed in a vehicle (continuous phase) bonded by an emulsifying agent, which is usually added, since, normally, two immiscible liquids cannot be dispersed for a long period [1]. It forms globules around the dispersed phase in order to scatter them indefinitely in the continuous phase in order to form a stable emulsion.

There are three types of emulsion which are oil in water in which the oil is the dispersed phase while water is the continuous phase; this is the other way in water-in-oil; multiple-emulsion which is a complex type of emulsion in which the oil-in-water or water-in-oil emulsions are dispersed in another liquid medium. A combination of hydrophilic and hydrophobic surfactant is used as stabilizers in multiple emulsions [2].

The percentage of creaming or coalescence occurring can be used to check the physical stability of an emulsion. Creaming is the process by which the dispersed phase separates out, forming a layer on the top of the continuous phase. In creaming, the dispersed phase remains can be re-dispersed on shaking. Creaming can be minimized if the viscosity of the continuous phase is increased [3]. Coalescence (cracking) occurs when the mechanical or electrical barrier is insufficient to prevent the formation of progressively larger droplets [4]. Coalescence may be avoided by the addition of high boiling point or high molecular weight components to the continuous phase [5].

Gums are considered to be pathological products, formed by giving injury to the plant or due to unfavourable conditions, such as drought, and by breakdown of cell walls (extra cellular formation: gummosis) [6]. Natural gums have some advantages in pharmaceutical sciences for its ready availability, cheap, safety and biocompatibility and biodegradability. Gums can be used pharmaceutically as surfactant, gelling agent, sequestering agent in detergents, binding agent and suspending agent, emulsifying agent and as thickening agent.

Gums are naturally available, biodegradable and environmentally friendly produced by most injured trees. They represent truly renewable source and they have no adverse impact on humans or environmental health (e.g. skin and eye irritation). Their continuous use as a pharmaceutical excipient will save my country from excessive foreign exchange.

*Raphia hookeri* gum is a type of natural gum from *Raphia hookeri* palm tree (common name Raffia palm, Family: Palmae). It is usually found in the western tropical Africa. Some natural gums have been used as an emulsifier in liquid paraffin emulsion. Olorunsola and Majekodunmi [7], working on the emulsifying properties of Afzelia gum in liquid paraffin emulsion found out that the gum is suitable for use at a concentration of 3% w/v as an emulsifier in 30% v/v liquid paraffin emulsion. *Raphia hookeri* gum has been successfully used as a binding agent in controlled release formulation [8]. Its use as an emulsifier in liquid paraffin emulsion has not been found in any literature. This study was undertaken to evaluate the emulsifying properties of Raphia gum in liquid paraffin emulsion.

### 2. Materials and Methods

#### 2.1 Materials

Materials used for this work are Raphia gum extracted from *Raphia hookeri* plant, acacia gum (Hopkin & Williams Ltd. England), Tween 80 (William Ranson & SON Ltd. England), liquid paraffin (Fishers Scientific Ltd. England). All other reagents are of analytical standard.

#### 2.2 Methods

##### 2.2.1 Collection, Extraction and Purification of Gum

The cut-down trunk of the tree *Raphia hookeri* was found at Ikot Obio Odongo, Ibekikpo Local Government Area of Akwa-Ibom state, Nigeria. The exudated gum was collected and allowed to dry in the
shade. The dried gum was washed and dried in hot air oven (Jenway Ltd. England, Serial No: 4122, Model: 3305) at 40 °C for 48 h. The gum was then reduced in size and hydrated in double strength chloroform water for 5 days with periodic stirring. The mucilage obtained was filtered through a clean calico cloth and the gum was precipitated with 95% w/v acetone (Fishers scientific Ltd. England). The precipitated gum was then filtered, washed with diethyl ether (Tianjin Kermel Chemical Reagent Development Center, China) and was then dried at 50 °C in hot air oven. The dried gum was pulverized and passed through sieve size 250 µm [9].

2.2.1 Preparation of Liquid Paraffin Emulsion with Containing Different Concentrations of Gum

Liquid paraffin emulsions (200 mL) were prepared with different concentrations of Raphia gum and acacia gum as shown in Table 1. The appropriate amount of the gum was weighed and transferred into a clean dried mortar. Liquid paraffin (60 mL) was measured and added to the gum inside the mortar and it was triturated together. Purified water (40 mL) was measured and added to the oil/gum mixture. The mixture was then transferred from the mortar into a beaker for homogenization. The mixture was homogenized for 5 min using a homogenizer (Silversons Machine Ltd. England with the model number L4R and serial no: 18225) to obtain the primary emulsion. The preparation was made to 200 mL by adding distilled water and homogenized further for 5 min.

2.2.2 Preparation of Liquid Paraffin Emulsions with Emulsifier Blend

Liquid paraffin emulsion (200 mL) was prepared using 60 mL liquid paraffin and various concentrations of Raphia gum and Tween 80 as emulsifier blend as shown in Table 2. The accurate quantity of the Raphia gum was weighed and put into a mortar containing liquid paraffin. The appropriate quantity of Tween 80 was measured, diluted with 60 mL of purified water and then added into the container containing the mixture of liquid paraffin and Raphia gum. The composite mixture of diluted Tween 80, Raphia gum and liquid paraffin was then triturated and transferred to a beaker and made up to 200 mL with purified water. Emulsification was effected by mixing each preparation for 5 min using a homogenizer (Silversons Machine Ltd. England with the model number L4R and serial no: 18225).

2.2.3 Evaluation of Emulsion

Determination of Density. The densities of the different emulsions were determined by weighing 50 mL of the emulsion. The sample was weighed using a weighing balance. The mass (g) obtained was divided by the volume of the emulsion.

Determination of Viscosity. The viscosities of the different emulsions were determined using a viscometer (Brookfield NDJ-5S Digital viscometer, model LVF with spindle at 60 rpm).

| Table 1  | Formula for emulsions containing different gum concentrations. |
|----------|---------------------------------------------------------------|
| Ingredients                  | Batch 1 | Batch 2 | Batch 3 | Batch 4 | Batch 5 |
| Liquid paraffin (v/v, %)      | 30      | 30      | 30      | 30      | 30      |
| Gum (v/v, %)                  | 1       | 2       | 3       | 5       | 10      |
| Water to (%)                  | 100     | 100     | 100     | 100     | 100     |

| Table 2  | Formula for emulsion containing emulsifier blend. |
|----------|---------------------------------------------------|
| Ingredient                  | Batch 1 | Batch 2 | Batch 3 | Batch 4 | Batch 5 |
| Liquid paraffin (mL)        | 60      | 60      | 60      | 60      | 60      |
| Raphia gum (g)              | 1       | 2       | 3       | 5       | 10      |
| Tween 80 (g)                | 5       | 4       | 3       | 2       | 1       |
| Water to (mL)               | 200     | 200     | 200     | 200     | 200     |
Table 3 Densities of liquid paraffin emulsions containing different gum concentrations.

| Gum conc. (w/v, %) | Acacia gum (g/cm³) | Raphia gum (g/cm³) |
|--------------------|--------------------|--------------------|
| 1                  | 0.92 ± 0.03        | 0.92 ± 0.02        |
| 2                  | 0.93 ± 0.02        | 0.94 ± 0.02        |
| 3                  | 0.96 ± 0.01        | 0.94 ± 0.01        |
| 5                  | 0.96 ± 0.01        | 0.94 ± 0.01        |
| 10                 | 0.98 ± 0.02        | 0.95 ± 0.02        |

N = 3; Results are expressed as mean ± standard error of the means.

Assessment of Stability. The emulsions were checked for both cracking and creaming in order to assess stability. A 50 mL volume of each preparation was transferred into 50 mL measuring cylinder and left for 5 days. The volume of the separated layer was determined and the percentage creaming was calculated as:

% creaming = \frac{\text{amount creamed (mL)}}{\text{total volume (mL)}} \times 100%

2.3 Statistical Analysis

Once the measurements were completed, data analysis was conducted in order to test whether there is any statistical difference between the means of tested properties of Raphia palm gum and acacia gum. To do this, the one-way analysis of variance was performed using Microsoft Excel software. The differences were taken to be significant if the p-values are less than 0.05.

3. Results

The results of the densities of liquid paraffin emulsion containing different concentration of acacia gum and Raphia gum are shown in Table 3. The results obtained showed that by changing the concentration of acacia and Raphia gum, their respective densities also varied. From the result, Fig. 1 also shows that by increasing the concentration of both gums—acacia and Raphia, the densities of emulsion formed also increase. The linear line checks on both gums clearly show that the changing concentration of acacia has a steeper slope with an average of 10%-15% change in density for every concentration change. The viscosities of liquid paraffin emulsions containing different concentrations of Acacia gum and Raphia gum are shown in Table 4. There was a significant difference in the viscosity of the emulsions containing different concentrations of Acacia gum and Raphia gum.

The result of the stability test on the emulsion containing different concentration of acacia gum and Raphia gum is shown in Table 5. Cracking was observed in emulsion containing 1% w/v of Raphia gum while creaming was observed in 2% w/v of Raphia gum while no creaming was observed in the other concentrations.

3.1 Emulsion Containing Different Emulsifier Blend

The properties of emulsion containing different emulsifier blends are shown in Table 6. Polysorbate 80 also known as Tween 80 was used in order to assess its effect on liquid paraffin emulsion when used with Raphia gum. The viscosity, density and stability of liquid paraffin emulsion containing different emulsifier blend were checked. The result showed that the viscosity and density of the liquid paraffin emulsion were in an increasing manner as the concentration of Raphia gum was increasing while that of Tween 80 was decreasing. This result is similar to the work of Olorunsola and Majekodunmi [7] on emulsifying properties of Afzelia gum in liquid paraffin. Both Afzelia and Raphia gums possess excellent surface activity. From the result gotten it was seen that creaming occurred in emulsion containing 1%-10% w/v of the emulsifier blend. When compared with emulsion...
Fig. 1 Assessing the effect of concentration on the density of acacia and Raphia gum.

Table 4 Viscosities of liquid paraffin emulsions containing different gum concentrations.

| Gum conc. (w/v, %) | Acacia gum (mPa·s) | Raphia gum (mPa·s) |
|-------------------|--------------------|--------------------|
| 1                 | 45.07 ± 0.03       | 21.11 ± 0.03       |
| 2                 | 71.67 ± 0.27       | 62.09 ± 0.01       |
| 3                 | 83.10 ± 0.19       | 210.11 ± 0.02      |
| 5                 | 130 ± 0.10         | 477.10 ± 0.02      |
| 10                | 223 ± 0.19         | 480.00 ± 1.02      |

N = 3; Results are expressed as mean ± standard error of the means.

Fig. 2 Plot of viscosity vs. concentration of Raphia gum.
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**Fig. 3** Plot of concentration of Acacia gum vs. viscosity of emulsion.

**Fig. 4** Comparison of viscosities change with concentration of acacia and raphia gum

**Table 5** Conditions of liquid paraffin emulsions containing different gum concentrations after 5 days of storage.

| Gum conc. (w/v, %) | Acacia gum          | Raphia gum         |
|--------------------|---------------------|--------------------|
| 1                  | Cracked             | Cracked            |
| 2                  | Cracked             | 23% creamed        |
| 3                  | 29.9% creamed       | No creaming        |
| 4                  | 34% creamed         | No creaming        |
| 5                  | 48.5% creamed       | No creaming        |

**Table 6** Emulsion containing different emulsifier blends.

| Emulsifier blends | 1    | 2    | 3    | 4    | 5    |
|-------------------|------|------|------|------|------|
| Tween 80:Raphia gum | 5:1  | 2:1  | 1:1  | 1:2  | 1:5  |
| Density           | 0.92 ± 0.01 | 0.94 ± 0.02 | 0.95 ± 0.03 | 0.99 ± 0.44 | 1.00 ± 0.07 |
| Viscosity         | 10.70 ± 0.06 | 14.87 ± 0.04 | 18.68 ± 0.18 | 31.20 ± 0.60 | 41.43 ± 0.26 |
| % Creamed         | 0.50% | 0.49% | 0.42% | 0.41% | 0.38% |

*N = 3; Results are expressed as mean ± standard error of the means.*
containing similar concentration of Raphia gum it was seen that 3%-10% w/v gave an emulsion with better stability than the emulsions containing emulsifier blends.

4. Discussion

In relation to Stokes’ law Debnath (2019) stated that the creaming rate of suspended globules is inversely proportional to the viscosity. An increase in viscosity leads to a decrease in creaming or sedimentation. It was also said that gums or clay could be added to o/w emulsions to increase viscosity while for w/o emulsions resins or high melting waxes can be used. The emulsion containing 1%-2% w/v of acacia gum was more viscous than the emulsion containing similar concentration of Raphia gum but the emulsion containing 3%-10% w/v of Raphia gum was more viscous than that containing similar concentration of acacia gum. It can be said that the better stability that was observed in emulsion containing Raphia gum is linked to its viscosity. Creaming can be minimized if the viscosity of the continuous phase is increased [3]. This explains why the creaming reduced in Raphia gum emulsion as the viscosity increased making the emulsion more stable. In the case of emulsions containing different concentration of acacia gum the viscosity was increasing lower than that of emulsion containing similar concentration of Raphia gum hence making it less stable.

The amount of emulsifying agent in an emulsion has a great influence on the emulsion stability. At low emulsifier concentration, the emulsion is unstable because of agglomeration of the oil droplets. At high emulsifier concentration emulsion instability occurs because of rapid coalescence [10]. Better stability was observed in the liquid paraffin emulsion as the concentration of the gum increased. In the emulsion containing 1% w/v of acacia gum cracking was observed which means an instable emulsion but as the concentration of gum increased a more stable emulsion was observed with rate of creaming decreasing as the concentration increased. The stability of the emulsions containing Raphia gum also increased as the concentration of Raphia gum increased. Cracking was observed in emulsion containing 1% w/v of Raphia gum while creaming was observed in 2% w/v of Raphia gum while no creaming was observed in the other concentrations. In a work which was done by Olorunsola and Majekodunmi [7], coalescence of the oil globules (cracking) was observed with emulsions containing 5% w/v acacia gum and below while creaming was observed in 10% w/v acacia gum. It was also observed with emulsions containing 1% w/v Afzelia gum while different levels of creaming were observed with emulsions containing 2% w/v Afzelia gum and above. Concentrations of 1%-2% w/v acacia gum and 1% w/v Raphia gum are unsuitable for the formulation of liquid paraffin emulsions as cracking was observed with all these emulsions. Concentrations of 3%-10% w/v acacia gum and 2%-10% w/v Raphia gum are suitable for the formulation of liquid paraffin emulsions as cracking was not observed but creaming was observed with all these emulsions.

By increasing the concentration by 100% both gums showed 50%-100% increase in viscosity. The emulsion containing 1%-2% w/v concentration of acacia gum had a higher viscosity than that of Raphia gum with same concentration range. Emulsion containing 3%-10% w/v concentration of Raphia gum had a higher viscosity than that acacia gum of similar concentration range. Viscosity is one of the important rheological characteristics of pharmaceutical emulsion because it has an effect on the stability of emulsion. From the result in Table 4 (column 1), it can be seen that by increasing the concentration of the gum, the viscosity increases as well. This agrees well with Stokes’ equation that compares the drag force with concentration. The graph in Fig. 2 shows the relationship between the concentration of Raphia gum and viscosity. It is clearly seen from the graph that relationship is a linear one as represented by the
gridline. As the concentration increases, however, the viscosity of Raphia gum was increased. The highest viscosity is recorded at 10\% w/v. The graph in Fig. 3 is a plot of the concentration of acacia gum and viscosity. The concentration is increased gradually from 1\% w/v to 10\% w/v and the viscosity is also seen to increase linearly following straight line graph pattern. The highest viscosity was recorded in this study at 10\% w/v for Acacia palm gum. In Fig. 4, the effect of concentration on viscosity of Raphia gum was compared with that of acacia gum. From the plot, it can be seen that as the concentration increases, the viscosity also increases. However, the rate of increase in Raphia is higher than the rate of increase in Acacia palm gum. Raphia palm gum exhibits more change with increasing concentration than Acacia palm. Although at 5\% w/v, the increase in viscosity in Raphia gum upon further addition of emulsion component shows an incremental decline. That is from more than 100\% to less than 1\%. This is however not the case in Acacia palm gum—in this, the viscosity continues to increase with increasing concentration. Generally, we can see that the viscosity of liquid paraffin emulsion made with Raphia gum increases then stabilises at a higher concentration.

Griffin (1954) introduced a very useful system for the classification of surfactants on the basis of their solubility in water which is called hydrophyllic-lipophyllic balance (HLB) that denotes the relative affinity of the surfactant for oil and water. Emulsifying agents with HLB values of 3 to 6 are used for w/o emulsions. Whereas emulsifying agents with HLB values of 7 to 20 are used for o/w emulsions [11]. HLB values have also been useful in describing the functional properties of materials. For example, HLB values from 1 to 3 exhibit antifoaming properties, values from 7 to 10 exhibit good wetting properties, values from 13 to 20 act as solubilizers, and values from 13 to 15 function as detergents. According to the work done to determine the hydrophile-lipophile balance (HLB) value of Raphia hookeri Mann (Family: Palmae) gum by emulsification method, Olorunsola and Majekodunmi [7] found the HLB value of the gum fell within the range of 8-16 which is characteristic of oil-in-water emulsifiers. These explain the ability of Raphia gum to form oil-in-water emulsion type. Applications of oil-in-water emulsification include the formulation of fats and oils for oral administration, formulation of oils for intravenous administration and formulation of water-soluble drugs for topical application. The oil-in-water emulsions for oral administration are more pleasant to take in this form, those for intravenous use have good flow and those for topical administration do not have a greasy texture and are easily washed from skin surfaces [7, 12].

5. Conclusion

From the research carried out it was noticed that the concentration of gum added to an emulsion affects both the density and viscosity of the emulsion thereby affecting its stability. The stability of an emulsion is a very important parameter because an unstable emulsion is not safe for usage. Pharmaceutical emulsion stability is characterized by the absence of coalescence of dispersed phase, absence of creaming and retaining its physical characters like elegance, odour, colour and appearance [13]. From the result obtained it is seen that emulsion containing 3\%-10\% w/v of Raphia gum is more viscous than that containing acacia gum of similar concentration. This high viscosity of the emulsion has a great role to play in its stability that is why no creaming or cracking was observed in the emulsions containing 3\%-10\% w/v Raphia gum. Also, from the outcome of the research it can be inferred that 3\%-10\% w/v concentration of Raphia gum will make a stable emulsion whereas in the case of emulsions containing 3\%-10\% w/v acacia gum creaming was observed. The stability of Raphia gum was checked by addition of Tween 80 (a surfactant) and it can be inferred that liquid paraffin emulsion with 3\%-10\% w/v of Raphia gum is more
stable than that with the emulsifier blend. A general conclusion drawn from the set of tests conducted indicates that Raphia gum is a good alternative to the well-known emulsifying agent, such as acacia and Afzelia gum.

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