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Determination of Hydrophile - Lipophile Balance Value of *Raphia hookeri Mann (Family: Palmae)* Gum by Emulsification Method

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article.

Abstract

Background: The hydrophile-lipophile balance (HLB) value is the major determinant of the applications of surfactants and any material that has potential for surface activity.
Objective: To determine the HLB value of *Raphia hookeri Mann (Family: Palmae)* gum by emulsification method.
Methods: Exudates of *Raphia hookeri* were collected and the gum was extracted and purified via dissolution in water, precipitation using ethanol, defatting using diethyl ether, oven-drying and pulverization. The pH and viscosity of 3 %w/v dispersion of the gum were determined in comparison with those of Tween 80 and Span 60. Series of emulsions were formed with the gum and Tween 80 as well as the gum and Span 60, in varying ratios of 1:5, 1:2, 1:1, 2:1 and 5:1. The emulsions were kept for 5 days at room temperature after which they were assessed for stability by checking the extent of creaming. The most stable emulsion was selected and the fractions of gum and standard surfactant incorporated were used for calculating the HLB value of the gum.
Results: The pH of 3 %w/v dispersions was in the order: *Raphia hookeri* gum < Span 60 < Tween 80 while the viscosity of the dispersion of *Raphia hookeri* gum was found to be more than four folds higher than those of Span 60 and Tween 80. The most stable emulsion was found to be the one containing Raphia gum and Tween 80 in ratio of 5:1 and the HLB value of the gum was found to be 11.44.
Conclusion: *Raphia hookeri* gum is more acidic and produces more viscous dispersion compared to Tween 80 and Span 60. The HLB value of the gum falls within the range of 8 - 16 which is characteristic of oil-in-water emulsifiers.
Keywords: *Raphia hookeri Mann*, Gum, Hydrophile-lipophile balance, Emulsification.

INTRODUCTION

The ability of surfactants to reduce interfacial tension is responsible for their use as emulsifiers, wetting agents, detergents, solubilizers, *et cetera* (Kaci *et al*., 2014). The application of a particular surfactant or any material that has potential for surface activity depends mainly on its hydrophile-lipophile balance. In the HLB system introduced by Griffin (1949), each surfactant can be assigned a number between 1 and 20 depending on the hydrophilicity or lipophilicity of the interfacial barrier offered by the surfactant. By means of these numbers, an HLB range of optimum efficiency for each class of surfactants has been established as: 2-3, 3-6, 7-9, 8-16, 13-15 and15-18 for anti-foaming agents, water-in-oil emulsifiers, wetting agents, oil-in-water emulsifiers, detergents and solubilizers respectively (Attwood, 2007).
The theory behind HLB is that emulsifiers or surfactants having low HLB value tend to be oil-soluble while those having high values tend to be water soluble (Griffin, 1954). However, this is not always right. For instance, two emulsifiers with same HLB value might exhibit different solubility characteristics. Also, chemical group alone does not establish hydrophile-lipophile balance. Furthermore, detergents may range from strongly hydrophilic for sodium laurate to strongly lipophilic for aluminium oleate while esters and ethers may range from low to high HLB values (Kruglioaokor, 2000). Therefore, it is important to experimentally determine the HLB value of a material which has surface activity to know its appropriate application.
According to Ndon (2003), *Raphia hookeri Mann* (Raffia palm) is the largest palm in Africa and is restricted to the tropical rainforest which is its ideal ecological condition. The plant is widely distributed in lowland swamps of western and central Africa. It is one of the most economically important plants in Africa. All parts of the plants are heavily utilized for many purposes from building materials to food and wine. The root extract of Raffia palm is used in trado-medicine for the treatment and prevention of several diseases. It is normally given to infants for the treatment of stomach pain (Akpan *et al*., 1996). Also, because of the effect of

the root extract in reducing plasma level of ethanol, it is used in the treatment of acute and chronic ethanol intoxication (Joo, 1984). In some parts of West Africa especially Ghana, the leaf juice is used for the treatment of laryngitis and lactation failure. Boiled fruits are eaten in many parts of Nigeria. The oily mesocarp is used in traditional medicine for its laxative and stomachic properties and as a liniment for pains. The ash of burnt and ground roots mixed with palm oil is instilled into the ear for the treatment of otitis (Akpan *et al*., 1996).
Although not much information is available on the use of *Raphia hookeri* gum, the exudates can be used as an additive in food and cosmetic industries (Akpabio *et al*., 2012). The proper use of the gum will depend majorly on its hydrophile-lipophile balance value which is unknown at the moment. The aim of this research is to determine the HLB value of this gum by emulsification method.

MATERIALS AND METHODS

Collection of *Raphia hookeri* exudate

Raphia hookeri exudate was collected from Odobo, Okobo in Akwa Ibom state, Nigeria. It was authenticated by the Taxonomist in the Herbarium of Department of Pharmacognosy and Natural Medicine, University of Uyo, Uyo, Nigeria where voucher number UUPH8e was given to the specimen.

Extraction of the gum

Raphia hookeri gum was extracted from the stem exudate of the plant and purified using the method described by Olorunsola *et al*. (2014).The exudate was cleaned by removing the bark and other extraneous materials by hand and then dried in a hot air oven (Gallenkamp, Germany) at 70 °C for about 24 h when it became sufficiently brittle.
The dried exudate was processed by milling into fine powder in a blender (Christison, United Kingdom). The fine powder (200 g) was dissolved in 2000 ml of water and allowed to stand for 20 h with intermittent stirring. The gum mucilage was strained with calico to remove insoluble debris and impurities and then precipitated with 1160 ml of 100 % ethanol. The precipitated gum was washed with 200 ml of diethyl ether and dried in hot air oven (Gallenkamp, Germany) for 24 h. The dried gum was blended with a laboratory blender (Christison, United Kingdom) and screened through a 250 µm sieve. The percentage yield was calculated using the equation:

$$Yield = \frac{Mass\,of\ gum\,obtained}{Initial\ mass\,of\ the\,exudate} X\ 100\,\% .. \qquad (1)$$

Characterization of *Raphia hookeri* gum

pH of surfactant dispersions

The pH of 3 %w/v dispersion of *Raphia hookeri* gum, Tween 80 and Span 60 were determined after preparation using a pH meter **(**Philips DZS-706 multi-parameter analyzer).

Viscosity

The viscosity of the 3 %w/v dispersions were determined at 27.4 °C using a viscometer (Brookfield NDJ-5S Digital viscometer), model LVF (with spindle #2) at 60 rpm.

Preparation of emulsions

Oil-in-water emulsions were prepared based on Table 1 using liquid paraffin as the oily phase and various combinations of *Raphia hookeri* gum with Tween 80 and *Raphia hookeri* gum with Span 60 as emulsifier blends. The emulsifier blends were of ratio 1:5, 1:2, 1:1, 2:1 and 5:1.
The appropriate quantity of the gum was weighed and distributed in the oily phase contained in a stainless steel cup. The calculated quantity of Tween 80 or Span 60 was measured, diluted with 60 ml of water and then triturated with the oily phase. The volume was made up to 200 ml with water. Emulsification was effected by mixing each preparation for 5 minutes using a homogenizer (Silversons Machine Ltd., England).

Table 1: Emulsion formula

S/N	Ingredients	Quantity (%)
1	Liquid paraffin	30
2	Emulsifier blend	3
3	Water to	100

Evaluation of emulsion stability

A 50 ml volume of each preparation was transferred into 50 ml capacity cylinder and left for 5 days. The stability of each preparation was determined on the basis of degree of creaming. The volume of the separated layer was determined and the percentage creaming was calculated as:

$$\%\ crea\min g = \frac{Amount\,creamed\ (ml)}{Total\,volume(ml)}\,x\,100\,\% \qquad ....(2)$$

The preparation with the least creaming was noted.

Determination of HLB value of *Raphia hookeri* gum

The HLB value was determined using the method of Griffin (1954) as described by Momoh and Adikwu (2008). The most stable emulsion was selected and the HLB value of *Raphia hookeri* gum was calculated by substituting in equation 3.

$H_A A = H_R - H_B B$ **……………………** (3)

Where

H_A = HLB of *Raphia hookeri* gum

A = Percent of the gum expressed as a decimal or fraction

H_R = Required HLB of liquid paraffin

H_B = HLB of Tween 80 or Span 60

B = Percent of Tween 80 or Span 60 expressed as a decimal or fraction.

RESULTS AND DISCUSSION

Yield

The exudate of *Raphia hookeri* gave a yield of 28 % w/w gum. This yield is lower than the gum yield from exudate of *Anacardium occidentalis L*. It is however, higher than the gum yield obtained from *Khaya senegalensis*. A gum yield of 48 % w/w was obtained from *Anacardium occidentalis L.* while 25 % w/w was obtained from *Khaya senegalensis* (Olorunsola *et al*., 2014). The differences in the yields could be attributed to the fact that exudates from different plants have different compositions (Olorunsola *et al*., 2014).

Physicochemical properties of the gum and surfactants

The pH and viscosity of 3 %w/v dispersions of *Raphia hookeri*, Tween 80 and Span 60 are shown in Table 2.

Table 2: Physicochemical properties of 3 %w/v gum and surfactants

S/n	Gum/Surfactant	pH	Viscosity (mPaS)
1	*Raphia hookeri*	4.09	208.60
2	Tween 80	6.35	42.52
3	Span 60	5.23	48.28

The pH of 3 %w/v dispersions was in the order: *Raphia hookeri* < Span 60 < Tween 80. This means that *Raphia hookeri* gum is more acidic compared to Span 60 and Tween 80. Knowledge of the pH of an excipient is an important parameter in determination of its suitability in formulation since the stability and physiological activity of most preparations depend on pH (Billany, 2007). For instance, lanzoprazole is more stable when formulated with a basic excipient (Zhou, 2009). Hence, *Raphia hookeri* gum might be less suitable for formulation of such medicinal agent.

The suitability of a substance as a thickener depends on the viscosity of its dispersion (Builders *et al*., 2009). The viscosity of the dispersion of *Raphia hookeri* gum is more than four folds higher than those of Span 60 and Tween 80. Hence, a far smaller amount of the gum will be needed to bring forth the same viscosity offered by a given amount of Span 60 or Tween 80. The use of the gum as a viscosity enhancer is therefore economical. The gum is a good thickener and might be suitable for use in confectionery; and as a suspending agent and an emulsifying agent in pharmaceuticals.

Viscosity value is also a useful measure of flow and pourability (Femi-Oyewo *et al.*, 2004). The limitation of highly viscous products in terms of pourability is the difficulty of dispensing them from narrow-mouthed containers. Therefore, dispersions containing *Raphia hookeri* gum will be less pourable compared to those of Tween 80 and Span 60.

High viscosity is needed for stability of emulsions and the viscosity of the continuous phase is directly related to the stability of emulsion (Billany, 2007). The high viscosity of the dispersion of Raphia gum is an indication that the gum might be suitable for formulation of a stable emulsion. The high viscosity of the dispersion is in consonance with the work of Billany (2007) where it was stated that hydrophilic colloids are viscosity enhancers and that this property is part of their emulsifying capability.

Characteristics of paraffin oil emulsions

The creaming levels of paraffin oil emulsions containing binary mixtures of emulsifying agents are shown in Table 3. The emulsion with the least creaming level was found to be gum: Tween 80 in ratio of 5:1 and the one with the highest level of creaming was found to be gum: span 60 in ratio of I: 5. The most stable emulsion in the series was determined on the basis of degree of creaming. The best or most stable emulsion of a given series is the one with the least degree of creaming (Udeala and Uwaga, 1981). As the proportion of the gum relative to Span 60 increased, the percentage of creaming decreased. Also, as the proportion of the gum relative to Tween 80 increased, the percentage of creaming decreased.

Tween 80 and Span 60 were chosen for the formation of binary mixtures of emulgents so as to take care of situations where HLB value of *Raphia hookeri* gum is lower than 12 or higher than 12 respectively. Tween 80 has an HLB value of 15, Span 60 has a value of 4.7 while the required HLB (HLB of paraffin oil) is 12. If the HLB value of *Raphia hookeri* gum is less than 12 then the most stable emulsion will contain *Raphia hookeri* gum and Tween 80. If otherwise, then it will contain *Raphia hookeri* gum and Span 60.

Table 3: Creaming levels of emulsions containing binary mixtures of emulgents

S/N	Binary mixtures		Vol. of creaming (ml)	% creaming
1	**Gum : Span 60**	1:5	31	62
2		1:2	29	58
3		1:1	14	28
4		2:1	3	6
5		5:1	1	2
6	**Gum :Tween 80**	1:5	29	58
7		1:2	27	54
8		1:1	19	38
9		2:1	1	2
10		5:1	0	0

HLB Value

The most stable emulsion (one with the least creaming level) was found to be that containing gum: Tween 80 in ratio of 5:1. The HLB value of *Raphia hookeri* gum can be calculated by substituting in equation 3 already given as:

$H_A A = H_R - H_B B$

Where

H_A = HLB value of *Raphia hookeri* gum

A = Percent of the gum expressed as a decimal or fraction (5/6 or 0.833)

H_R= Required HLB value of liquid paraffin (12)

H_B= HLB of Tween 80 (15)

B= Percent of Tween 80 expressed as a decimal or fraction (1/6 or 0.167)

Therefore,

$H_A \times 0.833 = 12 - (15 \times 0.167)$

$H_A \times 0.833 = 12 - 2.505$

$H_A \times 0.833 = 9.495$

$H_A = \frac{9.495}{0.833}$

$H_A = 11.439$

The calculated HLB value of *Raphia hookeri* gum is 11.44. The value is within the range of 8 – 16 which is best fitted for oil-in-water emulsifying agents (Adikwu *et al*., 1992).

This range is typical of most exudate and seed gums. For instance, khaya gum had been found to be characterized by HLB value of 15.91 (Olorunsola *et al*., 2014) while prosopis gum is characterized by HLB value of 11.26 (Olorunsola *et al*., 2015).

The oil-in-water emulsifiers, where Raphia gum has been found to belong, are used in the formulation of oil-in-water emulsions (Momoh and Adikwu, 2008). Fats and oils for oral administration either as medicament or as vehicle for oil-soluble drugs are formulated as oil-in-water emulsions. They are more pleasant to take in this form; and the inclusion of a flavourant in the aqueous phase will mask any unpleasant taste. Emulsions for intravenous administration must be the oil-in-water type. Also, water-soluble drugs for topical application for their local effects are formulated as oil-in-water emulsions. The oil-in-water topical preparations do not have greasy texture and are easily washed from skin surfaces (Billany, 2007). Therefore, oil-in-water emulsifiers such as Raphia gum are important pharmaceutical excipients.

CONCLUSION

The physicochemical properties of *Raphia hookeri* gum qualify the gum as a good pharmaceutical excipient. The most stable emulsion contains *Raphia hookeri* gum and Tween 80 in the ratio of 5:1. The HLB value of the gum is 11.44 which is in the range of HLB values of oil-in-water emulsifying agents and the gum could be used as such.

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