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Original Article

Ethnobotany of raffia palm (*Raphia hookeri*), productivity assessment and characterization of raffia palm oil from the Niger Delta, Nigeria

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Abstract
Raffia palm (*Raphia* sp) occurs abundantly in the wild in the freshwater zone of the Niger Delta, Nigeria. This study was carried out to assess the use, biomass productivity and characterization of raffia palm oil. Ripe raffia palm fruits were sampled from the three core Niger Delta States (Bayelsa, Delta and Rivers). The oil was extracted using mechanical method and was characterized. Results show that the relative density of the oil was 0.8700 – 0.9039, free fatty acid (FFA) content of 1.13% (Delta), 6.92% (Bayelsa) and 9.74% (Rivers), acidity value of 2.26% in Delta state, 13.94% in Bayelsa state and 19.48% in Rivers state (P<0.05), iodine value of 26.79% was recorded in the raffia palm oil from Rivers state, 28.60% from Bayelsa and 31.10% from Delta state. The peroxide value of the raffia oil was 5.58 mg KOH/g (Rivers state), 7.22 mg/KOH/g (Delta state) and 7.68mg/KOH/g (Bayelsa state) (P<0.05). The saponification number was 25.16 mgKOH/g in the oil from Bayelsa, 32.72 mg KOH/g from Delta and 213.18 mg KOH/g for Rivers state (P<0.05). The parameters fairly fell within the Nigerian standard for vegetable oil. The wild palm has a biomass productivity of 933 trees/ha in Bayelsa and Delta states and 1066 trees/ha in Rivers, but the apparent differences was not statistically significant (P>0.05). Raffia palm is currently underutilized by indigenous people for building construction, production of brooms, basket, ropes and constriction of fish, crab and turtle traps. Edible insect larva is obtained from the palm. Palm wine and locally fermented gin are the major uses of raffia palm. We conclude that raffia palm can be utilized as second generation biofuel feed stock to mitigate food versus fuel conflicts.

1. Introduction

Raffia palm (*Raphia* sp) is among the most diverse and geographically wide spread palm. It is found in Africa, Asia and South American. Raffia palm is the largest palm in Africa [1], and grows abundantly in the wild in many parts of West Africa, particularly in tropical rainforest zone [3]. Raffia palm is listed among eleven indigenous palms in Nigeria including *Elaeis, Borassus, Raphia, Eremospatha, Phoenix, Calamus, Podococcus, Hyphaene, Ancistrophyllum, Sclerosperma* and *Oncocalimuns* [2]. There are over 20 species of raffia palm which originated from West Africa, but mainly one species is found in South America, *Raphia taedigera*, which resembles *R. vinifera* in habit, structure and phytochemicals particularly flavonoids[3].

Raffia palm is one of the most useful economically [1]. Like the oil palm (*Elaeis guineensis*), every part of raffia palm is important[2]. Indigenous people use the leaves as thatch, the trunk and fronds as poles for building, construction and firewood. Fibres called piassava obtained from the plant are used for weaving, production of traditional textiles, and for the production of various types of ropes for climbing, and tying. Brooms, baskets, sieve, and fishing traps are also made from raffia palm. Edible insect's larva including *Oryctes monocerus, O. warensis* and *Rhynchophorus* sp are obtained from dead/decaying raffia trunks and roots[4].

Details of the ethnobotany and the use of raffia palm by indigenous people in West and Central Africa can be found in many researches. [2,3,5]. But raffia palm is more reported as a source of sugary beverage called palm wine, which is commonly fermented to ethanol called local gin [1,2,6-10]. Ndenecho[5] in 2007 reported that palm wine is the principal product obtained from raffia palm. Obahiagbon [2] in 2009 reported that over 50 million persons in southern Nigeria consume palm wine, of which raffia alone contributes 20%. Although, all species of raffia palm can produce palm wine, but research have focused mostly on *R. hookeri* and *R. vinifera* [1,2,6-10]; Akpan and Usoh [11] in 2004 demonstrated in rabbits that aqueous extracts of *R. hookeri* increases metabolic clearance rate of ethanol in rabbits. Due to their ichthyotoxicity properties the mesocarp of raffia palm fruit is used as poison to stupefy fish for easy catch [12-17]. Raffia palm is now increasingly being considered for the production of vegetable oil for biodiesel production [18,19] and bioethanol [6].

Raffia palm perform several ecological functions that are poorly documented. Raffia palm provide habitats for edible insects[3] and many species of fresh water turtles and tortoises [20]. Ecologically, raffia palm occupy from freshwater zone to the transitional zone dominated by *Machaerium lunatus* and *Pandanus* sp and in certain instances occupy the fringes of mangrove swamps. Raffia help to moderate and control flooding and in certain instances where mangroves succumb to sea flooding, raffia palm provide the next line of defense.

Raffia palm produces feedstock that are important to the emerging bioenergy sector including bioethanol, vegetable oil, biodiesel and other biomass that could be converted to electricity and other energy carriers using thermochemical conversion technology of pyrolysis, combustion and gasification. But raffia palm is hapazanthic (hapaxanthic) i.e. after a period of vegetative growth, it produces inflorescence and fruit only once and dies [1-3]. Despite the economic and ecologic importance and the hapazanthic nature of raffia palm, little efforts have been expended on the domestication of the plant [3]. Due to the hapazanthic nature, potential biomass of raffia palm particularly the fruits are lost annually. Raffia palm provide alternative feedstocks for biofuels for effectively mitigating food versus fuel conflicts associated with first generation biofuel feedstocks. Hence, the aim of this study is to assess biomass productivity of wild raffia palm, extract and characterize the oil from the mesocarp of the fruit of wild raffia palm and document the ethnobotanical uses of raffia palm by indigenous people in the Niger Delta.

2. Materials and Methods

2.1 Field Sampling, Productivity Assessment and Use Assessment

Raffia palm were sampled from three states in the Niger Delta region of Nigeria from 3rd- 31st January 2013. Samples were collected from Wilberforce Island in Bayelsa state, Ahoada in River state and Sapele in Delta state. The fruit bunches were separated with cutlass, into sub-bunches for assessment. Productivity assessment was carried out by estimating the number of wild raffia palm /hectare, and the number and weight of bunches and sub-bunches per tree were measured. Participant observation, walk through survey and interview methodologies were used to assess the use of raffia palm [21,22].

2.2 Raffia palm oil extraction

The oil was extracted from ripe raffia fruit using mechanical method with equipment made of wood and screws (Figure 1).

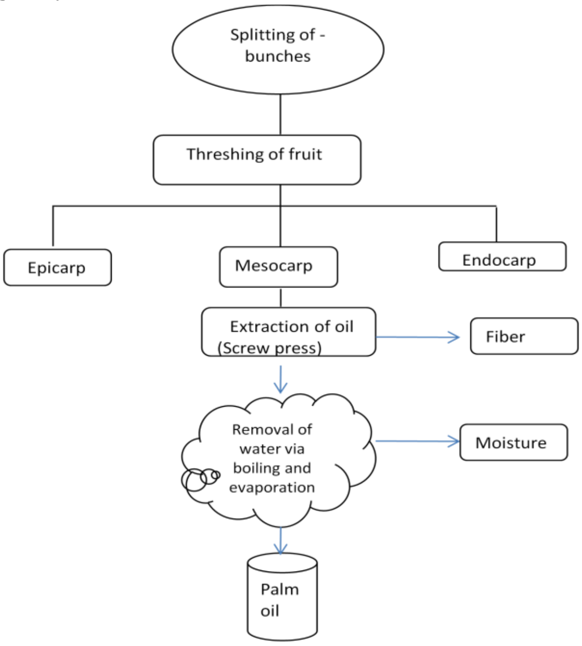


Figure 1: Raffia palm oil extraction

2. 3 Physicochemical Analysis

2.3.1 Saponification index determination

The saponification index was analyzed using the scheme provided by Pike [23]. About 2g of raffia palm oil were weight into excess 0.5M alcoholic KOH of about 25ml [24,25]. The fat was saponified by the application of heat [26]. The treated raffia palm oil samples were titrated with 0.5 M HCl using 1% phenolphthalein as indicator. A blank titration was also carried out. The weight of sample and titration values of the blank and samples were calculated as;

$$\text{Saponification value} = \frac{(S - B) \times N \times 56.1}{\text{Sample weight (g)}}$$

S = Sample titrated, B =Blank titration, N = Normal titration of the HCl, 56.1 = The Molar weight of KOH.

2.3.2 Acid value and free fatty acids:

The FFA of the raffia palm oil was determined by titration method. Alcohol was added to the raffia palm oil to form alcoholic solution of the oils and was titrated with aqueous solution of sodium hydroxide using phenolphthalein as indicator [25]. About 10g of the oil was weighed into the conical flask [25,26]. About 50 ml of alcohol ether mixture in equal volume was added, which was warmed to attain homogenity. This was titrated against 0.1M NaOH with the application phenolphthalein indicator. The titration was stopped when the pink end point was attained [25].

$$\text{\% FFA as palmtic acid} = \frac{\text{ml of NaOH x Molarity x 28.2mg}}{\text{Weight of sample}}$$

The acid value was obtained by multiplying the FFA by 2 [24].

2.3.3 Peroxide index analysis

The peroxide index was obtained via titration. Chloroform/glacial acetic acid/potassium iodide were added to the raffia palm oil and solution was formed. The solution was titrated against 0.01M sodium thiosulphate using starch as indicator. About 5g of oil was weighed into the 250ml conical flask. A mixture of glacial acetic acid and trichloromethane chloroform (30ml) was added in a ratio of 3: 2 [25] and about 0.5ml of saturated potassium iodide solution was also added and then swirled. Thereafter about 30ml of distilled water was added. A blank sample devoid of raffia palm oil was also analyzed using the same procedure. The peroxide value which is expressed as;

$$\text{Peroxide value (Meq Peroxide/kg)} = \frac{(S - B) \times M \times 1000}{\text{Sample weight}}$$

Where S = Sample titer
B = Blank
M = Molarity of sodium thiosulphate.

2.3.4 Specific gravity Analysis

Specific gravity was used to analyze the specific gravity of the raffia palm oil. The specific gravity bottles with glass stoppers were filled to the brim with the samples [25,26]. The specific gravity bottle containing the samples and containing distilled water were weighed separately on an analytical weighing balance (Metler Toledo) and the specific gravity (relative density) is expressed mathematically as;

$$\text{Specific gravity} = \frac{\text{Weight of oil sample}}{\text{Weight of water}}$$

2.3.5 Iodine value Analysis

The iodine value was determined by wijs' method using the scheme of Pike [23]. A moderate mixture of iodine monochloride and acetic acid were added to the raffia palm oil samples. The mixture was allowed to stand for 30 minutes in dark [25]. About 15ml of 10% potassium iodide was added to the mixture [24]. The solution was titrated with 0.1ml sodium thiosulphate solution using starch indicator. The end point (S) was recorded as sample titre. Analysis of Blank (B) was also carried out. The iodine value was mathematically calculated as;

$$\text{Iodine value} = \frac{(B - S) \times N \times 12.69}{\text{Sample weight (g)}}$$

Where B = blank titre value; S = sample titre value; N = normality of $Na_2S_2O_3$; 12.69 is used to convert from meq thiosulphate to g iodine; molecular weight of iodine = 126.9.

2.4 Statistical analysis

SPSS software version 17 was used to carry out the statistical analysis. Data were expressed as mean ±SE. A one-way analysis of variance was carried out at P = 0.05, and Post Hoc was carried out using Duncan Multiple Range Test.

3. Results and Discussion

All parts of raffia palm including the leaves, stem, fruits and roots are useful to the people of the Niger Delta, Nigeria (Table 1). Raffia palm provides light-weight construction materials for building, interior decorations and furniture, which will not pose any risk in the event of earthquake. The trunk are used as poles and pillars, the fronds (bamboo) are used as wood for the construction of roof, ceiling, bed and chairs, while the leaves are used as thatch for roofing, weaving of mats and production of brooms. The fronds are also used for the production of poles, traps, baskets and sieves. The fibres of the plant are used for the construction of different types of ropes. The trunk and roots are habitats for growth of edible insects' larva, which is a delicacy in the Niger Delta. There were no observable differences in the uses of raffia palm among the 3 major Niger Delta states. Palm wine, fermented alcoholic beverage and local gin are among the most reported use of raffia palm. Ndon [3] in 2003 and Obahiagbon [2] in 2009 reported the various ethnobotanical uses of raffia palm in Nigeria, while Ndenecho [5] in 2007 reported its use in Cameroun. The fruit of the raffia is mostly used as poison to stupefy fish for easy catching. This use has been reported by other authors. [12-17].

Table 1: Traditional uses of raffia palm in the Niger Delta

Plant parts	Uses	Bayelsa State	Delta State	Rivers State
Leaves	Broom	X	X	X
	Thatch for roofing	X	X	X
	Mat weaving	X	X	X
Fronds (bamboo construction material used for)	Fencing	X	X	X
	Ceiling	X	X	X
	Bed	X	X	X
	Chair	X	X	X
	Table	X	X	X
	Basket	X	X	X
	Roofing	X	X	X
	Door	X	X	X
	Gate	X	X	X
	Traps	X	X	X
Trunk	Fire wood	X	X	X
	Pole	X	X	X
	Traditional medicine	X	X	X
	Palm wine	X	X	X
	Local gin	X	X	X
	Habitat for edible insect larva	X	X	X
Fruits	Fish poison	X	X	X
	Food	X	X	X
Fiber (piassava)	Fish traps	X	X	X
	Hats	X	X	X
	Climbing ropes	X	X	X
	Other types of ropes	X	X	X
Roots	Habitat for edible insect larva	X	X	X

Table 2 presented the productivity of wild raffia palm (*Raphia hookeri*) in the 3 major Niger Delta states. The wild palm was 933 trees/ha in Bayelsa and Delta and 1066 trees/ha in Rivers, but the apparent differences was not statistically significant (P>0.05). The palms typically bear 4 -7 number of bunches per tree. There are about 31 – 34 number of sub bunches in a bunch (Fig. 2). There are about 5 different levels of sub bunches with each having different numbers of fruit. The first level, have up to 50 fruits, the second level 40 fruits, third level 30 fruits, fourth level 20 fruits and the fifth level often end as 1 fruit (Table 3). Hence, the high variability observed in their mean values. On the average, there is 29 – 33 numbers of fruits in a sub-bunch, which are not statistically different in the 3 Niger Delta states. The total number of fruit in each bunch ranged from 520 – 640, but are not statistically different (P>0.05) among the 3 core Niger Delta states. The total weight of each bunch is 103.48 – 108.640kg again not statistically different among the 3 core Niger Delta states. Fruits accounted for 89 – 91% of the total bunch, while chaff and other biomass such as non-fruit parts of the bunch accounting for the rest. The total length of the bunch ranged from 143.43 – 150.80 cm, not significantly different (P>0.05) among the 3 Niger Delta states. The sub-bunches are 29.4 – 30.92 cm long. Literatures are scarce on the productivity of wild raffia palm. But Ndon [3] in 2003 reported that raffia palm is very prolific and that a single tree can bear 500 – 5000 fruits. Conceicao *et al*[18] in 2011 estimated the productivity of *Raphia taedigera* Mart to be 300 metric tonnes/km^2/year.

Table 4 presents the features of raffia palm fruits. The weight of individual fruit was 69.14 g in Delta state and 121.48 g in Bayelsa and Rivers states (P<0.05). The length from the long axes ranged from 10.64 – 11.59 cm being not significantly different (P>0.05) in the 3 core Niger Delta states. Conceicao *et al*[18] in 2011 reported that raffia palm fruit (*R. taedigera*) have an average weight of 45g and contain about 1.5% oil.

Table 2: Productivity assessment of wild raffia palm in the Niger Delta

State	Productivity, No. of trees/ha	NSB, No	TFB, No	WFB, kg	WCB, kg	TWB, kg	NFSB, No	LB, cm	LSB, cm
Bayelsa	933.33±66.67a	31.80±3.02a	620.80±51.86a	89.02±4.28a	10.10±4.42a	103.48±5.67a	29.00±9.58a	143.46±18.27a	30.02±5.01a
Delta	933.33±120.19a	31.00±4.40a	520.80±99.51a	87.26±6.42a	9.98±4.26a	104.84±5.86a	31.80±9.62a	146.32±19.71a	29.40±5.13a
Rivers	1066.67±88.19a	34.00±2.61a	640.00±46.83a	91.92±3.73a	11.30±4.73a	108.68±5.07a	33.00±9.61a	150.80±19.24a	33.92±5.08a

Mean ±SE, n =5. Along the column, means with the same alphabets are not significantly different (P>0.05) according to Duncan Multiple Range Test

Abbreviation: NSB = number of sub-bunches in a bunch; TFB=total fruit in a bunch; WFB=weight of fruits in a bunch (weight of fruits alone); WCB=weight of chaff in a bunch; TWB =total weight of bunch (weight of fruits + others); NFSB= No. of fruit in sub-bunches; LB=length of bunch; LSB=length of sub-bunch (average)

Table 3: No of sub-bunches (NFSB) in raffia palm fruit bunch

Levels	Bayelsa state	Delta state	Rivers state
1st	53	56	56
2nd	42	43	45
3rd	36	39	40
4th	13	20	23
5th	1	1	1

Table 4: Features of raffia palm fruit

State	WOF, g	LOF, cm	WOFoE, g	WOE, g	LOS, cm	WOM, g	WOS, g
Bayelsa	121.48±9.12b	11.59±0.79a	99.30±9.54b	30.54±2.86a	11.01±0.48b	28.48±4.47b	48.37±3.70b
Delta	69.14±9.50a	10.64±0.56a	53.67±9.59a	24.17±2.69a	8.90±0.48a	14.97±3.16a	30.41±3.63a
Rivers	121.48±9.12b	11.59±0.79a	99.30±9.54b	30.54±2.86a	11.01±0.48b	28.48±4.47b	48.37±3.70b

Mean ±SE, n=10. Along the column, means with the same alphabets are not significantly different (P>0.05) according to Duncan Multiple Range Test
Abbreviation: WOF – Weight of Fruit; WOFoE – Weight of Fruit without epicarp; LOF – Length of Fruit; WOE – Weight of Epicarp; LOS –Length of Seed; WOM – Weight of Mesocarp; WOS –Weight of Seed

Ten (10) randomly selected fruits were used for oil extraction (Table 5). The volume and weight of oil produced was different (P<0.05) in the 3 states. The volume and weight of oil produced was highest in the palms from Rivers states followed by Bayelsa state and the least was recorded in Delta state. The reason for this difference is unknown. The oil was slightly bitter. Ndon [3] in 2003 also observed that raffia oil is slightly bitter. The physicochemical properties of the oil extracted from raffia palm obtained from 3 core Niger Delta states is presented in Table 6. The relative density of the oil was 0.8700 (Delta State), 0.8770 (Bayelsa State) and 0.9039 (Rivers State) (P<0.05), which fell with the Standard Organization of Nigeria/ Nigeria Industrial Standards (SON/NIS) for vegetable oil specific gravity of 0.897 – 0.907 [27]. Igwenyi *et al* [19] in 2008 reported a relative density of 0.8023 – 0.9229 for raffia palm oil, whereas Conceicao *et al*[18] in 2011 reported a specific mass of 0.9166 g/cm^3 for raffia oil and 0.8910 for palm oil. Ndon [3] in 2003 reported a density of 0.867 g/ml for *R.hookeri*, 0.863g/ml for *R. sudanica*, 0.860 g/ml for *R. regalis* and 0.877 for *R.vinifera* and 0.900g/ml for *Elaeis guineensis*.

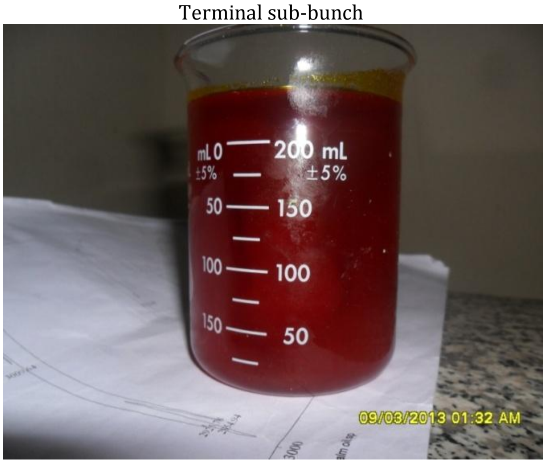
Raffia palm fruit bunch

Raffia palm sub-bunch

Empty fruit bunch

Terminal sub-bunch

Ripe raffia palm fruits



Raffia palm oil

Figure 2: Raffia palm fruit bunch and oil

Table 5: Raffia palm oil extracted from 10 randomly selected fruits

State	Volume of oil, ml	Weight of oil, kg
Bayelsa	28.48±0.01b	25.00±0.06b
Delta	14.97±0.00a	13.03±0.03a
Rivers	33.19±0.33c	30.00±0.58c

Mean± SE, n=3. Along the column, means with the same alphabets are not significantly different (P>0.05) according to Duncan Multiple Range Test

The raffia palm oil have FFA content of 1.13% (Delta), 6.92% (Bayelsa) and 9.74% (Rivers) which are significantly different (P<0.05). Igwenyi *et al*[19] in 2008 reported a FFA value of 0.85 – 2.54 mgKOH/g for. Vinifiera oil, whereas SON/NIS standard is .5mgKOH/g [27]. Ndon [3] in 2003 reported FFA values of 10.2 for *R. hookeri*, 5.2% for *R. sudanica*, 0.5% for *R. regalis*, 4.7% for *R. vinifera* and 0.5 – 18% for *Elaeis guineensis.* The value of FFA reported in raffia palm oil is comparable to what have being previously reported for *Elaeis guineensis* oil palm; 2.73 – 2.83 mgKOH/g [27], 8.43% [25], 2.73 – 2.89 [28]; 13.9- 19.8% [29].

The raffia palm oil in this study had an acidity value of 2.26% in Delta state, 13.94% in Bayelsa state and 19.48% in Rivers state (P<0.05). Igwenyi *et al* [19] in 2008 reported a low acid value of 1.65 – 5.05 mgKOH/g for *R. vinifera* oil. Conceicao *et al* [18] in 2011 reported acidity index of 8.0 mgKOH/g for raffia palm oil and 0.3 mgKOH/g for palm oil. For *Elaeis guineensis* oil palm, acid values reported in literatures is 20.00 [30].

In this study, iodine value of 26.79% was recorded in the raffia palm oil from Rivers state, 28.60% from Bayelsa and 31.10% from Delta state (P<0.05), which is within range of SON/NIS standards of 45 – 53 Wij's number [27]. Igwenyi *et al* [19] in 2008 reported iodine value of 69.41 – 76.52 wijs number. Conceicao *et al* [18] in 2011 reported iodine index of 75.1 for raffia oil and 51 – 55 for palm oil. Ndon [3] in 2003 reported iodine value of 51.0ppm for *R. hookeri* oil, 83.8 ppm for *R. sudanica* oil, 70.2 ppm for *R. vinifera* oil and 54.9 ppm for *E. guineensis*. Other authors have reported the iodine value of *E. guineensis* including 60.90 gI_2/g [30], 16.75 – 16.97 wijs [31], 52.61 – 63.48 wijs [28], 51.17 [25] and 5.90 $gI_2/100g$ [32].

Table 6: Physicochemical characteristics of raffia palm oil

State	relative density	Saponification Number mg KOH/g	FFA, %	Acidity value, %	Peroxide value, mg KOH/**g**	Iodine value, %
Bayelsa	0.8770±0.01b	25.16±0.01a	6.92±0.01b	13.84±0.01b	7.68±0.01c	28.60±0.01a
Delta	0.8700±0.01a	32.72±0.01b	1.13±0.01a	2.26±0.01a	7.22±0.00b	31.10±0.01c
Rivers	0.9039±0.02c	213.18±0.01c	9.74±0.01c	19.48±0.01c	5.58±0.01a	26.79±0.01b

Mean± SE, n=3. Along the column, means with the same alphabets are not significantly different (P>0.05) according to Duncan Multiple Range Test

In this study, peroxide value of the raffia oil was 5.58 mgKOH/g in Rivers state, 7.22 mg/KOH/g in Delta state and 7.68mg/KOH/g in Bayelsa state (P<0.05). Igwenyi *et al* [19] in 2008 reported peroxide value of raffia oil to be 2.0 – 6.0 while Conceicao *et al*[18] in 2011 reported peroxide index of 13.0 $MeqO_2$ (kg) for raffia oil and 6.0 $MeqO_2$ (kg) for palm oil SON/NIS standards for peroxide value in vegetable oil is 10 Meq/kg [27]. Ndon [3] in 2003 reported peroxide value of 26.7 for *R. hookeri,* 5.7 for *R. sudanica*, 26.8 for *R. regalis*, 19.7 for *R. vinifera* and 0.50 for *Elaeis guineensis*. Other authors have similarly reported peroxide values for *Elaeis guineensis* oil including 4.9 [25], 7.90 – 8.80 Meq/kg [28], 19.81 – 19.90 Meq/kg [31] and 16.08 [30].

In this study, saponification number of raffia oil was 25.16 mgKOH/g in the oil from Bayelsa, 32.72 mgKOH/g from Delta and 213.18mgKOH/g from Rivers state (P<0.05) which is within the SON/NIS standard value of 195 – 205 mg/KOH/G [27]. Except for raffia oil from Rivers states, Igwenyi *et al* [19] in 2008 reported a high saponifcation number of 214.58 – 263.20 mgKOH/g for raffia oil. Ndon [3] in 2003 similarly reported high saponification values of 198 for *R. hookeri* oil, 130 for *R. sudanica* oil, 186 for *R. regalis* oil, 201 *for R. vinifera* oil and 195 – 205 for *Elaeis guineensis* oil. Similarly, Conceicao *et al*. [18] in 2011 reported a saponification value of 193.0mgKOH/g for raffia oil and 190.0 – 209.0 mgKOH/g for palm oil. Other authors have also reported high saponfication values of palm oil including 195 – 198 mgKOH/g [27], 140 mgKOH/G [30] 192.64 – 198.03 mgKOH/g [28]; 218.3 – 242.7 mgKOH/g [29] and 192.05 mgKOH/g [25].

4. Conclusion

In this study, wild raffia palm occurring in the Niger Delta was studied in the three core states of the Niger Delta. Results show that raffia palm is used in the same way in the three states. The oil was characterized and was found to fairly fall within the SON/NIS standards for vegetable oil. We conclude by suggesting further studies on the oil especially on potability and use as biofuel feedstock.

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