Physicochemical Properties and Fatty Acid Profile of African Elemi Fruit Pulp Oil Compared with Palm Kernel Oil

D. B. Kiin-Kabari, P. S. Umunna, and S. Y. Giami

***Abstract* — African elemi (*Canarium schweinfurthii*) fruit pulp oil was extracted and refined which yielded 39.5% oil. It was characterized for its physical, chemical, phytochemical properties and fatty acid profile in comparison with palm kernel oil (PKO). The result for physical properties revealed that there was no significant difference in the density, refractive index, and flash point of the oils. African elemi fruit pulp oil (AEO) had significantly ($p>0.05$) higher slip melting point and viscosity while significantly ($p<0.05$) lower smoke point and fire point. Chemical properties of the oils such as iodine, acid value, unsaponifiable matter and free fatty acids were significantly ($p>0.05$) higher in AEO with the values of 76.79 g/100 g, 0.94 mg KOH/g, 1.32 and 0.58%, respectively and significantly ($p<0.05$) lower in saponification and peroxide values, 155.47 mg KOH/g and 1.06 meq/kg, respectively compared to the values obtained for the PKO. Saturated fatty acid profile of AEO had the values of 9.44, 32.24 and 2.63% for myristic (C14:0), stearic acid (C18:0) and palmitic acid (C16:0) while PKO had the values of 48.00, 16.20, 2.50 and 8.40% for lauric (C12:0), myristic (C14:0), stearic acid (C18:0) and palmitic acid (C16:0), respectively. The monounsaturated fatty acids were oleic acid (C18:1) 30.24% for AEO and 15.0% for PKO making oleic acid the highest occurring monounsaturated fatty acids present in AEO. Thus, lauric acid (C12:0) and linoleic (C18:2) was not dictated in AEO while gadoleic (C20:1) was not dictated in PKO. Flavonoids, tannins, saponins, phytates and alkaloids had the values of 0.29, 0.33, 0.13, 0.13 and 0.74% for AEO and 0.32, 0.12, 0.24, 0.11 and 0.07% for PKO, respectively and all were within the acceptable limit of 3% for food products with respect to the phytochemical properties of the oils. The result for solid fat content - temperature profile revealed that PKO and AEO completely melted at 35 °C and 45 °C, respectively.**

***Index Term* — African elemi fruit pulp oil, Palm kernel oil, Iodine value, Melting point, Fatty acid profiles.**

I. INTRODUCTION

African elemi (*Canarium schweinfurthii*) is of the burseracae family, a perennial plant which is widely distributed in the East Central and West Africa. In Nigeria, the plant is found in parts of Middle Belt, South East and South West regions of the country [1]. It is a large forest tree plant with its crown reaching to the upper canopy of the forest and its diameter is 4.5 meter. The slash is reddish or light brown with turpentine like odor, excluding a heavy sticky oleoresin that colors to sulphur yellow and becomes solid [2]. The local names for the plant in Nigeria include 'atile' in Hausa, 'ako' in Yoruba, 'ubemgba in Igbo and 'oda' in Idoma. Different parts of the plant such as leaves, barks, roots and fruits have been used variously as medicine, food, ornaments and fuel [3].

African elemi is one of the wild fruits, rich and bountiful in the South East and yet underutilized without much thought given to its nutritional values. As well as its benefits to the food industries, due to lack of information on its potential food uses. It has been reported that wild seeds and fruits offer a convenient but cheap means of providing adequate supplies of minerals, fat, protein, and carbohydrate to people living in the tropics [4]. African elemi pulp oil contains natural flavors, high fat content of about 39-40%, pigments, moisture, nutritionally valuable minerals, vitamins and naturally occurring antioxidants [5].

A significant proportion of diverse foods available in the environment have been neglected as technological options focuses on a few staple foods to address the problem of food security and hunger. There is need to look inwards for locally available foods that are nutritious, cheap, and easy to prepare to combat malnutrition. This work is aimed at characterizing African elemi pulp oil in comparison with palm kernel oil in terms of their oil contents, physical, chemical, and phytochemical properties, as well as the fatty acid contents – temperature profile.

II. MATERIALS AND METHODS

A. Collection of Materials

Fresh fruits of African elemi (*Canarium schweinfurthii*) were obtained from Ariaria International market, Aba in Abia State, Nigeria. Palm kernel oil was obtained from Rivers State Vegetable Oil (RIVOC), Trans Amadi, Port Harcourt. These were transported to the Department of Food Science and Technology Laboratory, Rivers State University, Port Harcourt, Nigeria for processing and analysis. The chemicals and reagents used were of food and analytical grades manufactured by BDH Limited, Poole England.

B. Methods

a) Sample Preparation

De-pulping and extraction of African Elemi fruit pulp oil (AEO) was achieved using the warm press method described by Catsberg and Dommellen [6] with some modifications. The fruits were sorted, dirt and foreign materials were removed and washed in cold water to further remove dirt. The fruits were packed in a clean bowl and hot water at 65 ºC was poured into the bowl. They were left for 20 min to soften the fruit tissues and then de-pulped from the seeds. The pulp was pounded using mortar and pestle (1.5 heights) for 10 min. The pounded pulp was dried in a hot air vacuum oven at 80 ºC for 1 h to remove any available free moisture. Cooled in desiccators and transferred to a screw press expeller where the pulp was pressed separating the oil from the paste. The extracted oil was packed and set outside for refining.

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b) Refining of the African Elemi Fruit Pulp Oil (AEO) using Chemical Method

The extracted AEO was refined using the procedure described by O'Brien (2004) with few modifications. The AEO was heated with 8% $NaOH_{(aq)}$ for 10 min with continues stirring using a laboratory stirrer (model JKL 2146 REM motors, India). The treatment was then washed with warm water until a neutral pH was achieved. The aqueous phase was separated using a separating funnel, the oil was then dried and bleached using 3% fullers earth and stirred continuously at 80°C for 20 min. It was then filtered at a temperature of 50 °C using Whattman No 4 filter paper to obtain a greenish refined oil that was used in the formulation of the margarine product.

c) Physicochemical Properties of African Elemi Oil

Physical properties analysed were density, refractive index, flash point and smoke point using the standard AOAC [7] method while, melting point, viscosity and fire point were carried out using the AOCS [8] method.

Chemical properties such as iodine value, acid value, saponification value, unsaponifiable matter, free fatty acid and peroxide value were equally determined using the AOAC [7] standard method while the method described by Nazaruddin [9] was used to determine the solid fat content - temperature profile.

d) Phytochemical Properties

Phytochemicals such as saponins, total alkaloid, flavonoid and tannins were determined using the methods described by Obadoni and Ochuko [10], Harborne [11], Oyetayo and Ibotoye [12] and Nwokonkwo [13], respectively.

e) Fatty Acid Profiles of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

The fatty acid analysis was carried out using a Perkin Elmer XL, Gas Chromatography (USA), equipped with FID. ADEGS packed column with nitrogen as carrier gas and flow rate at 22.6 ml/min, column temperature at 160 °C and detector temperature at 200 °C. Samples were compared with the gas chromatogram response to available fatty acid methylester standards.

Fatty acid methyl esters (FAME) were prepared from the extracted oil in 50 ml round bottom flasks. Fifty milligrams of each sample were kept in separate flasks and 3 ml of sodium methylate solution (0.5 mol/l of methanolic solution of NaOH) was added. The reaction medium was refluxed for 10 min. Three milliliter of acetyl chloride was then added and refluxed again for 10 min and cooled to ambient temperature. Eight milliliters of hexane and 10 ml of distilled water was added and allowed to stand for 5 min to establish a two phase solution. The upper organic phase was recovered into a vial for GC analysis.

f) Statistical Analysis

All data obtained were subjected to one-way Analysis of Variance (ANOVA) using MINITAB version 16 statistical package. Results were recorded using standard deviation of triplicate determinations and the means separated using Turkey's Multiple Range Test.

III. Results and Discussion

A. Physical Properties of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

There was no significant (p>0.05) difference in the density (g/ml) and the refractive index of the AEO and PKO samples as presented in Table 1. Slip melting point of the oil samples indicated that the extracted AEO melted at 30.67 °C while palm kernel oil (PKO) melted at 23.67 °C. Pure compounds usually display sharp melting points while impure compounds show broad melting point. Thus, the more saturated a fat is, the higher the melting point at room temperature [16]. The result showed that AEO has a better melting point over PKO which makes it acceptable in the formulation of margarine. The expected slip melting point of a good margarine is between 32-35 °C and if not, the margarine will break. The viscosity of the AEO had significantly (p<0.05) higher value of 0.368 Pa.s compare to that of the PKO with the value of 0.266 Pa.s. Palm kernel oil had higher flash point value of 328 °C compared to that of the AEO (291.67 °C). Although, these flash point values showed no significant difference between each other. The smoke and fire points of the PKO had significantly (p>0.05) higher values of 249.99 °C and 291 °C, respectively compared to the extracted and refined African elemi fruit pulp oil.

TABLE 1: Physical properties of AEO and PKO

Samples	Density (g/ml)	Refractive Index	Slip Melting Point (°C)	Viscosity (pa.S)	Flash Point (°C)	Smoke Point	Fire Point (°C)
AEO	$0.907^{a}\pm0.04$	$1.40^{a}\pm0.00$	$30.67^{a}\pm1.53$	$0.368^{a}\pm0.04$	$291.67^{a}\pm9.61$	$197.00^{b}\pm10.54$	$197.00^{b}\pm10.54$
PKO	$0.884^{a}\pm0.04$	$1.43^{a}\pm0.02$	$23.67^{b}\pm0.58$	$0.266^{b}\pm0.03$	$328.00^{a}\pm9.85$	$249.99^{a}\pm13.53$	$291.00^{a}\pm60.70$

Mean score that do not share a letter along the column are significantly different (p < 0.05) ± standard deviation of triplicate determinations.
Key: AEO =African Elemi Pulp Oil, PKO = Refined Palm Kernel Oil.

B. Chemical Properties of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

The result for chemical properties revealed that African elemi fruit pulp oil (AEO) had significantly (p<0.05) higher acid value compared to that of palm kernel oil (PKO) as presented in Table 2. Acid value is used to measure the extent to which glycerides in the oil has been decomposed by lipase and other actions such as light and heat. The determination of acid value is often used as a general indication of the condition and edibility of oils. The lower the acid value, the better value of the oil for edible purposes. However, the results obtained showed low acid values in both AEO (0.94 mgkoH/g) and PKO (0.40 mgkoH/g) with significant (p>0.05) difference. The maximum acid value for a food grade oil/fat is between 9 and 10 mg [17]. Higher value than this, is an indication that the oil/fat has gone rancid and will not be good for use in the production of food products. Free fatty acid values are important in determining the use of oils for industrial or edibility purpose. Acid value of oil suitable for edibility purpose should not exceed 0.4% as oleic [18] while the maximum value for free fatty acid acceptable in oil/fat is 3%. The free fatty acid and acid value of the pulp oil were not high, and this suggests that the oil would have a long shelf life. The findings then suggest that oils from African elemi pulp will be suitable for margarine formulation and production.

Peroxide value correlates with the extent to which oxidative rancidity has taken place in oil. Thus, a measure of the shelf life of the oil. The low peroxide value for African elemi in this research showed that its oil would have a long shelf life. The oils are, therefore, free from odour and flavor in its content. The peroxide value obtained for AEO (1.06 meq/kg) and PKO (2.01 meq/kg) falls within the range of 2.7-7.4 mg/KOH/kg reported for some locally processed Nigerian palm oils [19].

TABLE 2: CHEMICAL PROPERTIES OF AEO AND PKO

Samples	Iodine Value (g/100g)	Acid Value (mgKOH/g)	Saponification Value (mgKOH/g)	Unsaponifiable Matter (%)	Free Fatty Acid (%)	Peroxide Value (meq/kg)
AEO	76.79^{a}±9.10	0.94^{a}±0.3	155.47^{b}±9.47	1.32^{a}±0.36	0.58^{a}±0.03	1.06^{b}±0.04
PKO	15.13^{b}±1.57	0.40^{b}±0.11	248.33^{a}±3.06	0.13^{b}±0.07	0.31^{b}±0.04	2.01^{a}±0.04

Mean values bearing different superscripts in the same column differs significantly (p<0.05) ± standard deviation of triplicate samples.
Key: AEO = African elemi pulp oil, PKO = Palm kernel oil.

C. The Fatty Acid Profile of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

Stearic acid (C18:0) acid is the predominant fatty acid in AEO with the value of 32.24%, followed by oleic acid (C18.1) with the value of 30.24% as shown in Table 3. This finding is in agreement with that of Oyetayo and Ibitoye [12] who reported on the protective effects of oils extracted from canarium fruit pulps and kernel. The values of oleic and stearic acids obtained in this research is comparable with that of palm oil with oleic value of 39.0 as reported by Ayoade *et al.* [4]. African elemi oil can therefore be regarded as having 50% saturated and 50% unsaturated like palm oil. These qualities of African elemi oil can satisfy the current demand for zero trans fatty acid. The production process does not require any form of hydrogenation or esterification process that introduces trans fatty acid. The PKO has more of the lauric (C12.0) and myristic (C14.0) acids with the values of 48.00 and 16.20%, respectively. The presence of these fatty acids in PKO makes it hard at room temperature with a low melting point [20]. The melting points are related to the presence of carbon - carbon double bonds in fatty acid composition. From this study, African elemi fruit pulp oil (AEO) has shown to be more beneficial in the use for margarine production. Thus, does not require hydrogenation due to its fatty acid composition. The degree of saturation and the chain length of the fatty acids in the triglycerides found in foods are important determinants of the oil properties. The heavy content of lauric acid gives PKO its sharp melting properties, meaning hardness at room temperature combined with low melting point [21].

TABLE 3: FATTY ACID PROFILE OF AEO AND PKO

Fatty acids (%)	AEO	PKO
Saturated Fatty Acids		
Lauric (C12:0)	ND	48.00
Myristic (C14:0)	9.44	16.20
Stearic (C18:0)	32.24	2.50
Palmitic (C16:0)	2.63	8.40
Monounsaturated Fatty Acids		
Oleic (C18:1)	30.24	15.00
Linoleic (C18:2)	ND	3.00
Gadoleic (C20:1)	1.30	ND
Behenic (C20:0)	12.80	0.38

Key: AEO = African elemi fruit pulp oil, PKO = Palm kernel oil, ND = Not dictated.

D. Phytochemical Properties of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

The phytochemical properties of African elemi fruit pulp oil (AEO) showed that the phytates level is 0.13% as presented in Table 4, which is lower than 2.01% found in soybeans [22]. Phytic acid forms insoluble salt with essential minerals like calcium, magnesium, and iron in food, rendering them unavailable for absorption into the bloodstream. Phytates are destroyed by proper heat treatment and hydrolysis [23]. Flavonoid values showed no significant difference between AEO (0.29%) and PKO (0.32%). The tannin results obtained were 0.33% for African elemi fruit pulp oil (AEO) and 0.12% for the palm kernel oil (PKO). This level of tannin in AEO is higher compared to the range 0.15 - 0.20mg/100g as recommended by Schiavone *et al.* [24].

Osagie [25] reported that simple boiling removes alkaloids present in most cultivated species of plant foods. Alkaloids are basic natural products occurring in plants, generally found in the form of salts with organic acids. Onwuka [26] stated that about 10 - 20% of all higher plants probably contains alkaloids. The values are, however, higher than the values of tannin (0.16%) for tiger nut seeds reported by Addey and Eteshola [27] which are also consumed raw as a human food. Tannin may decrease protein quality by decreasing digestibility and palatability. Other nutritional effects of tannin include damage to the intestinal tract, toxicity of tannins absorbed from the gut and interference with the absorption of iron and a possible carcinogenic effect. Onimawo and Akubor [28] observed that tannins are responsible for the astringency of many foods such as apples, pears, tea, and cocoa. AEO was observed to contain 0.13% for both saponin and phytate, respectively. However, PKO had a significant high value of saponin (0.24%). These values are lower compared to the saponins value of 0.47mg/g reported by Osagie [25] found in bullet pulp oil (*Canarium schweinfurthii*). The alkaloid content of African elemi fruit pulp oil was 0.74%. This value falls with the range of alkaloid content of 0.78% for bullet pear reported by Ehirim *et al.* [29] while that of PKO in this study had significantly (p<0.05) lower value of 0.07%.

TABLE 4: PHYTOCHEMICAL PROPERTIES OF AEO AND PKO

Samples	Flavonoids %	Tannins %	Saponins %	Phytates %	Alkaloids %
AEO	0.29 ± 0.05^{a}	0.33 ± 0.37^{a}	0.13 ± 0.03^{b}	0.13 ± 0.04^{a}	0.74 ± 0.05^{a}
PKO	0.32 ± 0.07^{a}	0.12 ± 0.05^{b}	0.24 ± 0.03^{a}	0.11 ± 0.01^{b}	0.07 ± 0.02^{b}

Mean values bearing different superscripts in the same column differs significantly ($p<0.05$) ± standard deviation of triplicate samples.
Key: AEO = African elemi fruit pulp oil, PKO = palm kernel oil.

E. Solid Fat Content – Temperature Profile of African Elemi Fruit Pulp Oil (AEO) and Palm Kernel Oil (PKO)

The result for solid fat content and temperature profile revealed that African elemi fruit pulp oil (AEO) had a relatively good sloping range compared to that of palm kernel oil (PKO) as shown in Fig. 1. This could be as a result of its melting temperature. Thus, AEO showed a slow melting range from 20 ºC to 40 ºC where the slope became sharp and completely melted at 45 ºC, whereas PKO completely melted at 35 ºC. The result obtained here will aid greatly to understand the behavior of the margarine when AEO is blended with other ingredients in the formulation of margarine.

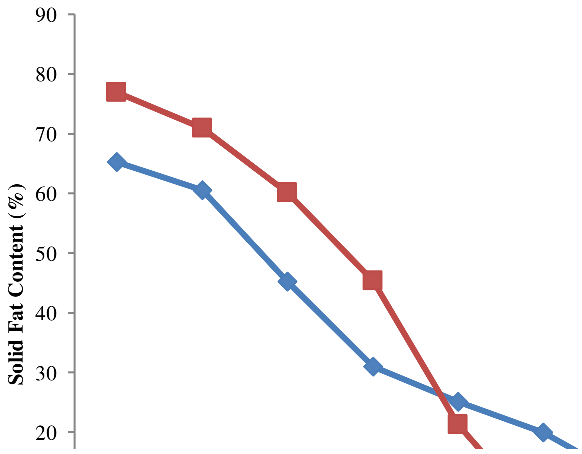

Fig. 1. Solid Fat Content (SFC) –Temperature Profile of AEO and PKO.
Key: AEO = African Elemi Fruit Pulp Oil, PKO = Palm Kernel Oil, SFC = Solid Fat Content.

IV. CONCLUSION

This study has shown that African elemi fruit pulp oil (AEO) has a high yield of oil and it is an indication that the pulps are good sources of vegetable oil. High iodine value of AEO is also an indication that the oil is rich in monounsaturated fatty acids and will contribute to the nutritional value of the oils. The study proved that AEO has 50% saturated fats as oleic acid and 50% unsaturated fat as stearic acid and less palmitic acid, making it a healthy source of solid base fat. The characteristics properties of AEO in terms of its melting point, iodine value and fatty acid profile gave an edge over some other oils in predicting its structural behavior in the formulation and production of margarine. Thus, study on margarine formulation using the studied oils is ongoing.

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