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Characterization of Edible Oils from Different Varieties of African Oil Bean Seeds

[1]Uzochukwu Onwuzuruike, [2]Ufot Evanson Inyang, [2]Edima-Nyah Peter, [1]Abasiekong Solomon, [1]Blessing Iguh and [2]Chibuzor Ihemeje

[1]Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia, Nigeria

[2]Department of Food Science and Technology, Faculty of Agriculture, University of Uyo, Uyo, Akwa Ibom, Nigeria

ABSTRACT

Background and Objective: Given the increasing demand for vegetable oils, investigations have been geared toward unconventional sources of vegetable oils to cushion the detrimental economic effect of the importation of these oils. This study, therefore, assessed the effects of variety on the phytochemical, physicochemical and fatty acid profile of oil extracted from three varieties of African oil bean (*ugba*) seeds. **Materials and Methods:** Edible oils were extracted from three varieties of African oil bean seeds: *ugba* Ghana, *ugba* Cameroon and *ugba* Nsukka. The oils were assessed for their oil yield, chemical properties, physicochemical properties and phytochemical properties while fatty acid profile was conducted for only *ugba* Ghana oil in consideration of its yield. **Results:** The oil yields were 50.23, 42.55 and 37.80% for *ugba* Ghana, *ugba* Cameroon and *ugba* Nsukka, respectively. Chemical properties ranged from 127.30 to 81.40 g/100 g for iodine value, 180.80-212.67 mg/KOH/g for saponification value, 3.52-6.45 meq O_2/kg fat for peroxide value, 2.14-4.53% for free fatty acid value, 0.84-3.72% for unsaponifiable matter and 0.04-1.12 mg/g for thiobarbituric acid value. Fatty acid profile of *ugba* Ghana oil showed that oleic acid (31.29%) was the most abundant fatty acid, followed by linoleic acid (28.69%), linolenic acid (14.1%) then tetracosapentaenoic acid (8.23%). Physicochemical properties ranged from 0.90 to 1.01 for specific gravity, 40.59 to 92.82 mPas for viscosity and 1.43-1.48 for refractive index. Phytochemical properties (mg/100 g) were alkaloid (0.00-8.42), total phenol (0.00-0.63), tannin (0.00-0.93), saponin (0.00-4.91), tocopherol (18.59-21.13) and flavonoid (0.16-0.92). **Conclusion:** The study has shown that variety had significant effects on the yield, physical, chemical and phytochemical compositions of the African oil bean seed oil.

KEYWORDS

African oil bean, fatty acid, phytochemicals, edible oils, chemical properties

INTRODUCTION

Vegetable oils are oils extracted from plant-based sources such as soybean, peanut, canola and sunflower[1]. They are sources of phytochemicals such as flavonoids and phenols as well as protective micronutrients like tocopherols which play important roles in cellular metabolism[2] as well as sources of calorie and fat-soluble vitamins like vitamins A, D, E and K[3].

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The market and demand for vegetable oils for domestic and industrial use is on a steady increase in most developing countries. This is due to the increasing awareness of its nutritional benefits and extended use in the food, soap, cosmetics and even the pharmaceutical industries[1]. Given the extended use of vegetable oils and the increasing demand for them, there is, therefore, the need to channel investigations and research towards the extraction of vegetable oils from unconventional oil crops to meet the increasing demand.

The African oil bean seed (*Pentaclethra macrophylla*) is one such unconventional oilseed that is being investigated for edible oil extraction. The crop is found mostly in the Southern and North Central regions of Nigeria and in other coastal parts of West and Central Africa where it is known by different local names. Among the Igbo people of the South Eastern part of Nigeria where the seed is used in the preparation of several indigenous cuisines such as *ugba*, it is known as *ugba* or *ukpaka*. The *ugba* which is mainly processed from African oil bean seed is consumed by all socioeconomic classes in Nigeria[4]. Some varieties of African oil bean seed present in local markets within Nigeria include but are not limited to, *ugba Igbo*, *ugba Nsukka*, *ugba* Ghana, *ugba* Cameroon and *ugba* Agbua.

Discovering an unconventional oil seed is one success matrix however, the oil yield of the seed is a major determining factor of its utilization as an oil seed. This is because oil yield is a significant factor in oil processing as it determines the profit margin for the manufacturer[5]. For instance, the oil yield of African oil bean seeds has been reported[6] to range from 34.00 to 51.70%. The oil yield of oil seeds has also been reported to be dependent on the moisture content, seed dimension, heating time and temperature[6]. The variety of the African oil bean and the oil extraction method employed has also been implicated in the variation in oil yield. It is useful to note that in the process of oil extraction from the oil seed, one critical process step in maximizing oil yield is the altering of the seed structure which increases the rate of mass transfer of lipids from the seed matrix[7]. Among the commonly used methods for edible oil extraction, Soxhlet extraction has been reported to provide better oil yield[8].

The oil extracted from African oil beans has been shown to have a good appearance as well as valuable fatty acid esters essential for human growth and development[9] and in addition, contains bioactives such as sitosterol, campesterol and stigma-sterol[10]. Nonetheless, despite its rich nutrient composition, viable oil yield and potential in many industries and domestic spheres, the African oil bean seed is still underutilized and its oil is yet to gain popularity amongst vegetable oil users in Nigeria and West Africa as a whole.

If fully harnessed, the African oil bean seed oil has the potential to save Nigeria and other vegetable oil importing countries where the African oil bean seed is an indigenous crop, the high economic downsides associated with the importation of vegetable oils and also, extend the utilization of the African oil bean seed from only being consumed as an indigenous food to an economic oil seed[10].

The objectives of this study, therefore, were to evaluate the effects of variety on the oil yield and physicochemical and phytochemical composition of oil extracted from three varieties of African oil bean seed.

MATERIALS AND METHODS

Study area: The study was carried out at Michael Okpara University of Agriculture, Umudike, Nigeria. The study duration was 5 months starting from April to September, 2023.

Material collection: Wholesome *ugba* Nsukka (Fig. 1), *ugba* Cameroon (Fig. 2) and *ugba* Ghana (Fig. 3) varieties of the African oil bean seeds were purchased from Ubani main market, Umuahia, Abia State between April and May. All reagents used for this study are of analytical grades.

Fig. 1: *ugba* Nsukka

Fig. 2: *ugba* Cameroon

Fig. 3: *ugba* Ghana

Processing of African oil bean seed into powder: The method described by Oyinlove and Enujiugha[11] was adopted in processing the African oil bean seeds to powder. The 6 kg each of *ugba* Nsukka, *ugba* Cameroon and *ugba* Ghana of African oil bean seeds varieties were manually sorted and washed with tap water, then air dried at ambient temperature. This was followed by dehulling carried out by cracking the seeds in a mortar, separating the cotyledons from the hulls using a knife then winnowing. The separated cotyledons were dried in an oven (Scanfrost, Model 5400, Germany) at 60°C for 6 hrs before milling into flour using an attrition milling machine (Corona Landers, Model 1925, England). The flours (Fig. 4-6) were packaged in an airtight Ziploc bag until needed for extraction.

Method of oil extraction: Oil extraction from the African oil bean flour was done following essentially the soxhlet extraction method described by Adepoju *et al.*[12]. The 400 mL of n-Hexane was measured into a 500 mL round bottom flask containing 100 g of each of the varieties of African oil bean seed flour. The Soxhlet apparatus (Borosilicate glass, Model 99036-00, England) was set up and heated at 60°C and allowed to run for 6 hrs. The resulting oil extract was heated in an oven (Scanfrost, Model 5400, Germany)

Fig. 4: *ugba* Nsukka

Fig. 5: *ugba* Cameroon

Fig. 6: *ugba* Ghana

Fig. 7: *ugba* Nsukka oils

at 80°C for 10 min for any residual n-hexane in the mix to evaporate. The oil samples (Fig. 7-9) obtained were cooled, weighed and packaged in an air-tight container and stored at 4°C awaiting analyses.

Fig. 8: *ugba* Cameroon oils

Fig. 9: *ugba* Ghana oils

Determination of oil yield: The oil yield of African oil bean mesocarp powder was determined by dividing the weight of the extracted African oil bean mesocarp oil by the weight of the African oil bean mesocarp powder used for oil extraction[13] as shown below:

$$\text{Oil yield (\%)} \frac{\text{Weight of oil}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of chemical properties: Saponification value was determined according to the method described by AOAC[14]. Peroxide value was determined following the of Ahmed *et al.*[15] method while iodine value was determined according to the method described by Hashempour-Baltork *et al.*[16]. The thiobarbituric acid value was determined according to the Montesano *et al.*[17] method while the unsaponifiable matter was determined following the method described by van Hoed *et al.*[18]. The free fatty acid and the fatty acid profile of *ugba* Ghana were determined according to the methods described by Lim *et al.*[19] and Nehdi *et al.*[20], respectively.

Determination of physicochemical properties: Specific gravity and refractive index were determined according to the method described by Yoshime *et al.*[21]. Viscosity was determined according to the method described by Mraihi *et al.*[22].

Determination of phytochemical properties: Alkaloid, tannin and saponin were determined according to the method as described by Ebajo Jr. *et al.*[23]. Flavonoid was determined by following the precipitate gravimetric method of Osuagwu and Ihenwosu[24] while total phenolic content and tocopherol was determined according to the Oyedeji *et al.*[25] method.

Experimental design and statistical analysis: Experimental design adopted for the study was the Completely Randomized Design (CRD). Experimental data were subjected to one-way Analysis of Variance

(ANOVA) using the SPSS version 20.0 software for personal computers. The analyzed data were expressed as means alongside their respective standard deviations. The Duncan's multiple range test was used to compare the means of experimental data at 0.05 level of probability.

RESULTS

Oil yield: The oil yield of African oil bean seed oil from different varieties (*ugba* Ghana, *ugba* Cameroon and *ugba* Nsukka) are presented. The values obtained differ significantly ($p<0.05$) among the varieties which can be attributed to varietal differences. The percentage oil yield for *ugba* Ghana variety was 50.23%, for *ugba* Cameroon variety was 42.55 and 37.80% for *ugba* Nsukka variety. The results from the present study therefore implied that Ghana variety had the highest oil yield.

Chemical properties: The chemical properties of oils extracted from the different varieties of African oil bean seeds are shown in Table 1. The iodine values, saponification values, unsaponifiable matter, peroxide values, free fatty acids and thiobarbituric acid assay were assessed in the extracted oils. The iodine values of the oils ranged from 127.30 to 81.40 g/100 g. Although there was no significant difference ($p>0.05$) in the Iodine values of *ugba* Cameroon and *ugba* Nsukka, *ugba* Ghana recorded the highest iodine value. The saponification values ranged from 180.80-212.67 mg/KOH/g and fell within the Codex range of values for saponification. The peroxide value ranged from 3.52 to 6.45 meq O_2/kg fat and these values fell below the recommended limit suggesting that the oil samples are still fresh. Free fatty acids ranged from 2.14-4.53%. The *ugba* Ghana variety had the highest value and differed significantly ($p<0.05$) from other varieties. There were significant differences ($p<0.05$) in the free fatty acid (FFA) contents of the oils. The FFA values ranged from 2.14-4.53% with *ugba* Ghana variety recording the highest value. Values of unsaponifiable matter (USM) ranged from 0.84-3.72% with *ugba* Cameroon recording a significantly lower value compared to the other two varieties. There were significant differences in the Thiobarbituric acid (TBA) values ranging from 0.04-1.12 mg/g. Thiobarbituric acid assay (TBA) is the most widely used method for the measurement of secondary oxidation products and may contribute to off-flavour of oxidized oils. Oil from *ugba* Ghana variety recorded the highest TBA value.

Fatty acid profile of *ugba* Ghana variety: The fatty acid profile of oil from *ugba* Ghana variety was analysed. This was because it contained the highest oil yield amongst the three African oil bean seeds. The results of the fatty acid analysis are presented in Table 2. There were significant differences in the fatty acid composition of the oil extracted from *ugba* Ghana variety of African oil bean seed. The results showed oleic acid to be the most abundant fatty acid (31.29%) while tetracosapentaenoic acid had the least value (8.23%) for fatty acids. There were also significant amounts of linoleic (28.69%) and linolenic (14.11%) acids present. The total saturated fatty acid (SFA) content was 9.11%.

Physicochemical properties: The physicochemical properties of the oils extracted from three African oil bean varieties are presented in Table 3. The specific gravity, viscosity and refractive indices of the oil extract were analyzed. The results showed significant differences in all the physicochemical properties of

Table 1: Chemical properties of the African oil bean seed oils

	Variety			
Chemical properties	*ugba* Nsukka	*ugba* Ghana	*ugba* Cameroon	Control
IV (g/100 g)	82.75 ± 1.48^{c}	101.50 ± 1.17^{b}	81.40 ± 1.64^{c}	127.30 ± 1.72^{a}
FFA (%)	2.94 ± 0.02^{c}	4.53 ± 0.01^{a}	3.51 ± 0.01^{b}	2.14 ± 0.04^{cd}
SV (mg/KOH/g)	181.60 ± 0.14^{c}	212.67 ± 0.14^{a}	182.10 ± 0.42^{b}	180.80 ± 1.69^{d}
USM (%)	3.60 ± 0.03^{b}	1.96 ± 0.01^{c}	3.72 ± 0.02^{a}	0.84 ± 0.01^{d}
PV (meq O_2/kg fat)	5.43 ± 0.00^{b}	6.45 ± 0.01^{a}	4.79 ± 0.04^{c}	3.52 ± 0.03^{d}
TBA (mg/g)	0.59 ± 0.02^{b}	1.12 ± 0.06^{a}	0.54 ± 0.01^{c}	0.04 ± 0.01^{d}

Table 2: Fatty acid composition (area%) of oil from *ugba* Ghana variety

Fatty acid	*ugba* Ghana (%)
Lauric acid (C12:0)	0.54±0.03
Myristic acid (C14:0)	2.65±0.11
Palmitic acid (C16:0)	3.51±0.09
Stearic acid (C18:0)	2.41±0.06
Oleic acid (C18:1 n-9)	31.29±1.11
Linoleic acid (C18:2 n-6)	28.69± 1.08
Linolenic acid (C18:3 n-3)	14.11±0.08
Eicosedienoic acid (C20:2 n-6)	0.60±0.01
Eicosatrienoic acid (C20:3 n-3)	3.84±0.03
Arachidonic acid (C20:4 n-6)	3.08±0.08
Docosahexaenoic acid (C22:6 n-3)	1.05±0.04
Tetracosapentaenoic acid (C24.5 n-3)	8.23±0.17
SFA	9.11
MUFA	31.29
PUFA	59.60
MUFA/PUFA	0.53
P/S Index	6.54

SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acids, P/S Index and the ratio of unsaturated to saturated fatty acids

Table 3: Physicochemical properties of African oil bean seed oils

	Physicochemical properties		
Varieties	Specific gravity	Viscosity (mPas)	Refractive index
ugba Nsukka	$0.90±0.01^{d}$	$91.72±0.02^{a}$	$1.43±0.01^{c}$
ugba Ghana	$0.94±0.01^{b}$	$91.80±0.01^{a}$	$1.44±0.01^{b}$
ugba Cameroon	$0.92±0.02^{c}$	$92.82±0.01^{a}$	$1.45±0.01^{d}$
Control	$1.01±0.01^{a}$	$40.59±0.05^{c}$	$1.48±0.01^{a}$

Values show the mean of duplicate analysis and±standard deviation. Figures with different superscript down the column are significantly different (p<0.05)

Table 4: Phytochemical properties of oils from African oil bean seed oil varieties

	Variety			
Phytochemical (mg/100g)	*ugba* Nsukka	*ugba* Ghana	*ugba* Cameroon	Control
Alkaloid	$5.97±0.02^{b}$	$8.42±0.04^{a}$	$5.91±0.01^{bc}$	$0.00±0.03^{c}$
Total phenol	$0.18±0.01^{b}$	$0.63±0.13^{a}$	$0.08±0.03^{c}$	$0.00±0.03^{d}$
Tannin	$0.13±0.01^{b}$	$0.93±0.01^{a}$	$0.14±0.04^{b}$	$0.00±0.02^{c}$
Saponin	$1.28±0.02^{b}$	$4.91±0.01^{a}$	$1.26±0.01^{b}$	$0.00±0.02^{c}$
Flavonoid	$0.91±0.01^{a}$	$0.77±0.01^{b}$	$0.92±0.02^{a}$	$0.16±0.01^{c}$
Tocopherol	$18.59±0.02^{c}$	$19.07±0.01^{b}$	$19.05±0.01^{b}$	$21.13±0.01^{a}$

Values show the mean of duplicate analysis and±standard deviation. Figures with different superscripts across the row are significantly different (p<0.05)

the oils assessed. The values for the specific gravity of the African oil bean oil extracts ranged from 0.90-1.01 with the control sample recording the highest value while *ugba* Nsukka recorded the least value. There were no significant differences in the samples in terms of viscosity except in the control sample. The refractive indices of the oils ranged from 1.43 to 1.48.

Phytochemical properties: The phytochemicals present in the oils extracted from the three African oil bean seed varieties were assessed and the results are presented in Table 4. There were significant differences ($p<0.05$) in the saponin, tannin, alkaloid and total phenol composition of the oil samples. There was no significant difference in the flavonoid composition of the oil extract from *ugba* Cameroon and *ugba* Nsukka recording the highest values while *ugba* Ghana recorded the least flavonoid value. Tocopherol which is commonly called vitamin E was least in *ugba* Nsukka however, there were no significant differences in the tocopherol composition of *ugba* Ghana and *ugba* Cameroon.

DISCUSSION

The oil yield of an oil seed is a very valuable property. The African oil bean seed has been shown to contain significant amounts of oil however, the method of extraction employed is one of the major determining factors of the oil yield and Soxhlet extraction has been reported to provide higher oil yield. This increased oil yield associated with Soxhlet extraction can be associated with the larger surface area resulting from the milling process which increases solvent penetration and also, the high temperature and long time which dissolves the fat globules allowing an extended time for sufficient extraction. Given that the same method of oil extraction was employed across the three varieties of African oil beans, the significant differences in the oil yields show that the variety of the oil seed significantly affects oil yield. In this study, the oil yield of *ugba* Ghana variety exceeded the value (47.90%) reported by Agarwal and Udipi[26] for African oil bean seed oil extracted through Soxhlet extraction method. A study by Duru[27] on the oil yield of African oil beans at different maturation stages of the seeds has shown that the African oil bean contained significant amounts of oil reaching up to 39.2% at full maturity. On the other hand, another report by Kar and Okechukwu[28] recorded a lower oil yield of 38.00%. The results of the chemical properties of the oils showed that there were significant differences in the saponification value (SV), unsaponifiable matter (USM), peroxide value (PV) and thiobarbituric acid assay (TBA) components of the extracted oils.

The Iodine value in this study can be described as the quantity of iodine absorbed by one gram of the oil to saturate the sigma bond. This is an indication of the level of unsaturation and the susceptibility of the oil to oxidation and rancidity. Therefore, a higher iodine value translates to a lower shelf stability of the oil. In this study, the Iodine value (127.30 to 81.40 g/100 g) of the oils were significantly higher than that (3.57-8.23 mg/100g) reported by Ukozor and Onyeka[29] for fermented *ugba* (P*entaclethra macrophylla* Benth) condiment oil extract and that (63.14 mg/100 g) reported by Ajayi and Oderinde[30] for *Pentaclethra macrophylla* seed oils; a good indication that the oils in this study may possess lower shelf stability. Hence, among the varieties studied, the oil extracted from *ugba* Ghana may have higher unsaturation and lower stability compared to other varieties.

The saponification value of oil defines its solubility in water, its soap formation, its molecular weight and its chain length[31]. The saponification values of the oils in this study were higher than the values (59.86-86.64 mg/KOH/g) reported by Ukozor and Onyeka[29] for fermented *ugba* (*Pentaclethra macrophylla* Benth) seed oil. In another report by Fabrikov[32], comparable values for unrefined corn oil (206.49 mg KOH/g) were reported but lower values for sunflower oil (177.1 mg KOH/g), canola oil (172.3 mg KOH/g) and peanut oil (179.8 mg KOH/g) were also recorded. According to Rezig *et al.*[33], the standard requirements for saponification value of unblended oil should fall within the range of 194-202 mg KOH/g and the saponification values recorded in this study for *ugba* oils can be said to be standard values.

The level of spoilage of oil is determined by its peroxide value (an index of rancidity) which measures fat stability by quantifying the hydroperoxides and peroxides formed at the initiation of an oxidation process. The peroxide values (3.52-6.45 meq O_2/kg fat) for oils in this study were lower than the range of values (5.16-18.68 meq O_2/kg fat) reported by Ukozor and Onyeka[29] for the peroxide value of fermented *ugba* (*Pentaclethra macrophylla* Benth) seed oil. According to the CODEX Alimentarius standard for vegetable oil[34], the maximum allowable limit of PV of fresh and refined vegetable oils is 10 meq O_2/kg fat. Therefore, the *ugba* oils in this study had peroxide values within the recommended limits an indication of freshness.

According to Codex Alimentarius Commission reported by Szabo *et al.*[34], the maximum reference value for free fatty acids (FFA) content is 0.5 to 5.00% for edible oils. This is because high FFA accelerates oxidation by decreasing the surface tension of edible oil and increasing the diffusion rate of oxygen from the headspace into the oil[35]. Although, the FFA contents of all the *ugba* oil samples fell within the codex limits, *ugba* Nsukka and *ugba* Cameroon varieties had lower FFA values inferring better and edible quality.

The unsaponifiable matter (USM) of an edible oil refers to the components of the oil which after alkaline hydrolysis of a fatty substance, is soluble in organic solvents but largely insoluble in aqueous solvents. In addition, if the USM of oil is high (i.e. >2%) such as in crude fats, there is a higher possibility of retarding the ability of the oil to produce soap that can lather easily[36]. Some vegetable oils have exceptional amounts of USM up to 5.0 to 6.0% even as the unsaponifiable fraction may typically constitute 0.5 to 2.5% of the vegetable oil[37] hence, it can be inferred that oil from *ugba* Ghana has better potential in soap making than those from the other *ugba* varieties.

Thiobarbituric acid assay is the most widely used method in the measurement of secondary oxidation products which may contribute to off-flavour of oxidized oils[38]. The *ugba* Ghana variety had a higher value which suggests a more pronounced occurrence of secondary oxidation and the presence of its subsequent products such as aldehydes and ketones.

The high oil yield of *ugba* Ghana variety of African oil bean seeds shows its potential to be adopted for industrial utilization. As a monounsaturated fatty acid, it has been shown that it has the potential of possibly increasing high-density lipoprotein cholesterol while lowering the low density lipoprotein cholesterol. Another study by Kim *et al.*[39] has also described oleic acid as an anti-apoptotic and anti-inflamatory agent. Although the oleic acid value was higher than the value (8.02%) reported in another study[40] on the fatty acid profile of gamma-irradiated and cooked African oil bean seed (*Pentaclethra macrophylla* Benth), it fell within the codex standard range of values (35.0-69.0 %) for the oleic acid composition of edible vegetable oil[34]. Linoleic acid value was lower than the value (53.63%) reported in another study by Olotu *et al.*[40] but still fell within the codex[34] standard (12.0-43.0 %). Linoleic acid is an important anti-inflammatory agent which has been reported to improve the immune system, help body defence, decrease blood cholesterol and prevent cardiovascular diseases[41]. The linolenic acid value of the oil from *Ugba* Ghana was lower than the value, of 24.55% reported for the linolenic acid value of the oil extracted from gamma-irradiated and cooked African oil bean seed (*Pentaclethra macrophylla* Benth)[40].

Tetracosapentaenoic acid belongs to the class of organic compounds known as very long chain fatty acids. Their presence in oil up to 8% may likely affect stability against oxidation. The value (3.08%) recorded for arachidonic acid was higher than the codex standard of 0.2-0.5% reported by Hilali *et al.*[42].

The most significant saturated fatty acid (SFA) swas palmitic acid (3.51%). The SFA with a chain length of 12 carbon atoms do not store in the body as fat and they have easy digestibility. Therefore, it is utilized largely for energy production in the human body[43]. The SFA with a longer chain length above 14 carbon atoms tends to agglomerate hence, resulting in a high probability of cardiovascular disease occurrence[44]. Consequently, a lower amount of long-chain SFA (palmitic and stearic) present in the oil would pose less risk to the cardiovascular system.

The oil stability of edible oils with a high level of unsaturation can be linked to the ratio of MUFA to PUFA parameter[45]. High values of MUFA/PUFA ratio signify a low level of PUFA and, thus, higher stability. In the current study, *ugba* Ghana oil variety had a MUFA/PUFA value of 0.53% which signified low oxidative stability. The fatty acid content was also expressed as P/S index. The P/S index is the ratio of PUFA to SFA in edible oil. It is an important parameter for determining the nutritional value of oil. Oils and fats with a high P/S index greater than 1 are considered to have nutritional value. Several studies indicated that a high P/S index indicates a smaller deposition of lipids in the body[46]. The P/S index for the oil was 6.54, indicating appreciable nutritional value.

In terms of physicochemical properties, values recorded for the specific gravity of the *ugba* oils compared with values (0.91 and 0.84) reported by Ebuehi *et al.*[47] for palm oil and groundnut oil respectively. A similar range of values (0.89-0.92) have also been reported for freshly processed palm oil[48] while 0.92 was also reported for the specific gravity of African oil bean seed oils[30]. Amongst the oils studied, the specific gravity of *ugba* Nsukka oil fell within the standard range of values (0.898-0.907)[49] for the specific gravity of vegetable oils. Specific gravity is particularly useful because it allows access to molecular information in a non-invasive way[50]. Viscosity is affected by the degree of unsaturation and chain length of fatty acids implying that a longer carbon chain and a decreasing degree of unsaturation results in an increase in viscosity[51,52]. Hence, *ugba* Cameroon oil can be said to be more saturated relative to *ugba* Ghana and *ugba* Nsukka oils since viscosity value increases with increasing degree of saturation. Refractive index of this study corresponded with other studies by resesrchers[30,53,54] that have also reported a similar range of values for the refractive indices of other vegetable oils such as oils from African oil bean (1.46), *Pentaclethra macrophylla* seed (1.47), sunflower (1.47), soybean (1.48) and sesame (1.47). Refractive indices of the oils in this study also were within the range of values (1.44 to 1.47) recommended by Codex[34] for the refractive indices of some named vegetable oils. Higher refractive index value recorded for control sample may suggest a higher level of unsaturation since refractive index is used mainly to measure the change in unsaturation as the fat or oil is hydrogenated[54]. Thus, the variation in refractive indices may be attributed to the difference in chain length of fatty acids in triglycerides[50].

The negligible amount of alkaloid, total phenol, tannin and saponin in the control sample (commercial oil) can be attributed to the refining process. The alkaloid contents of the *Ugba* oils varied significantly ($p<0.05$) from a report by Ellwood *et al.*[55], where a 0.51 mg/100 g alkaloid concentration for African oil bean seed was recorded. This difference in concentration can be due to the processing method employed and varietal differences amongst African oil bean seeds[56]. Interestingly, oil seeds containing alkaloids have diuretic, antispasmodic, anti-inflammatory and analgesic effects[57].

Higher range of values (0.325 to 6.378 mg/100 g) compared to values recorded in this study for total phenols in different legumes has been reported[58]. Phenols can delay or inhibit oxidation process of lipids by inhibiting the initiation or propagation of oxidative chain reactions[59]. However, another study by Cory *et al.*[60] suggested that a long–term intake of phenolics from diets could reduce the risk of certain diseases such as cancers, cardiovascular diseases, type 2 diabetes, osteoporosis and pancreatitis. Tannins are polyphenolic compounds characterized by their astringency, bitter taste and ability to bind or form precipitates with organic compounds such as alkaloids and amino acids[61]. In high concentrations, tannins may alter the intestinal digestion process and impair cellulose Huang *et al.*[36]. lower tannin content values (0.09 and 0.07 mg/100 g) have been reported for oils extracted from African oil bean seed[9,55]. However, the range of tannin content in this study falls within safe limits as it is far below the critical value of 7.3-9.0 mg/g reported by Quilez *et al.*[62]. Saponins on the other hand, reduce the bioavailability of nutrients, decrease enzyme activity and affect protein digestibility by inhibiting various digestive enzymes such as trypsin and chymotrypsin and can form complexes with zinc and iron, thus, limiting their bioavailability[63]. High saponin content in the crude oils suggests the need for refining. As components of fruit, vegetables, oil seeds and spices, flavonoids are regularly contained in human food as well as edible oils and may reduce the risk of various cancers, prevent menopausal symptoms and lower the risk of coronary heart diseases[64]. The higher tocopherol content of the control can be associated with the possible fortification of tocopherol by the manufacturers. Notwithstanding, the low tocopherol content of *ugba* oils suggests poor oxidative stability.

CONCLUSION

This study showed that variety had a significant influence on the edible oil obtained from African oil bean seed. The *ugba* Ghana had the highest oil yield and phytochemical properties. The quality indices of the African oil bean seed oils from all three varieties were within acceptable ranges. Oleic acid was the most abundant fatty acid, followed by linoleic acid then linolenic acid. Palmitic acid is the most significant saturated fatty acid. The overall findings showed that the oil is good for human consumption.

SIGNIFICANCE STATEMENT

The market and extensive use of vegetable oils for domestic and industrial purposes has been on a constant increase in the last decade hence, have resulted in the increased cost of vegetable oils and their importation in regions where some of the conventional oil seeds are not adequately cultivated. As a way of cushioning the economic impact of importation and optimizing other potential indigenous oil seeds, this study, therefore, explored three varieties of African Oil beans in Nigeria as unconventional sources of edible vegetable oil. The results showed significant oil yields from each variety with acceptable quality indices however, the variety of the African oil bean significantly impacted the oil yield and chemical, physicochemical and phytochemical properties of the oil extracts.

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