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Physicochemical properties and fatty acid profile of *Irvingia gabonensis* (Kuwing) seed oil

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Abstract
This study investigated the physicochemical properties and fatty acid composition of *Irvingia gabonensis* (Kuwing) seed oil. The oil was extracted using soxhlet extraction technique. The fatty acid profile analysis of the oil was carried out by Gas Liquid Chromatography. Results show that Kuwing seed oil is light yellow in colour, yielded 67.33±1.2, with a pH of 6.32±0.07 and a specific gravity of 0.85±0.03kg/dm^3. Relative density was 0.82 ±0.01 and refractive index was 1.37±0.01. The acid value was 11.35±0.03 mg KOH g^{-1} and iodine value, 4.18±0.02 mg iodine g^{-1}. The peroxide value was 2.67±0.03 meqkg^{-1} of oil. The saponification value was 181.9±0.21 mg KOH g^{-1}. The melting point was 13.34±0.01ºC, smoke point, 77.2±1.91ºC, and the freezing point, 165.97±0.30ºC, while the flash point was 120.03±0.50 ºC. It had free fatty acid content of 7.37±0.12%. No aflatoxins were recorded in the oil. The most abundant fatty acid was myristic acid (42.75±0.25%) followed by lauric acid (40.5±0.2%). In conclusion, Kuwing seed oil can be regarded as myristic-lauric oil, is of good quality and can be used for domestic and industrial purposes.

Keywords: fatty acid, *Irvingia gabonensis*, oil, physicochemical properties

1. Introduction
Irvingia gabonensis is a species of African trees sometimes known by the common names: native mango, bush mango, wild mango, African mango, African wild mango and Dikanut [1]. It is named differently in other countries. It is named oba in Gabon, sioko in Ivory Coast, wilder mango baum in Germany, Afurika mango no ki in Japan, and arbol chocolate in Spain [2]. In Nigeria, it is locally known as goron in Hausa, oro in Yoruba and ogbono in Igbo. The Agoi Ibami community of Nigeria call *Irvingia gabonensis* Kuwing [1].

The fruits of *Irvingia gabonensis* (Kuwing) can be eaten fresh as food. They can be further processed into jelly, jam, juice, and even wine. Ancient wines and liquors included the fruit juice of this herb, which was left to ferment for 28 days to obtain its alcohol content. Black dyes for cloth coloration can be prepared using the fruit pulp. The plant can be cultivated to control erosion, and to provide shade to cocoa and coffee plants. The seed endosperm when removed by cracking the seed coat can be eaten raw or roasted, but most times they are pounded to butter-like or chocolate-like block. Seeds can be pressed to produce edible oil (solid at ambient temperature) or margarine used for cooking. This oil can then be processed further to soap or cosmetics. By pressing oil out of the seeds a press cake is left behind which can be used as cattle feed or as thickening agent for soup. The seeds of *Irvingia gabonensis* when crushed can also be used as a thickening and flavouring agent in soups and stews [3, 4]. Apart from the edible usefulness of *Irvingia gabonensis* seeds, there are other useful purposes it serves. For instance, *Irvingia gabonensis* seeds have been found to play anti-diabetic roles - helpful in reducing fasting blood glucose levels in obese persons - as well as helpful in weight management, and regulating serum cholesterol levels. This was shown in a double-blind randomized study of 40 obese human subjects. 28 subjects received 1.05g *Irvingia gabonensis* seed extract three times a day for one month while 12 subjects were on placebo on the same schedule. The obese patients given *Irvingia gabonensis* seed extract had a sufficient decrease in fasting blood glucose, triglycerides, total cholesterol, LDL-cholesterol, with an increase in HDL-cholesterol. However, the placebo showed no changes in blood glucose and lipid components [5]. Also, it has been proven by research that *Irvingia gabonensis* seeds delay stomach emptying, leading to a more gradual absorption of dietary sugar. This effect can reduce the elevation of blood sugar levels that is typical after a meal [6].

Furthermore, all parts of a typical *Irvingia gabonensis* tree such as the bark, leaves, seeds and seed kernels are used for medicinal purposes. The bark of this tree contribute antibiotic properties and hence is very effective for treating skin bruises, the boiled bark is used to cure toothaches while the outer portion of stem bark and leaves are ingested orally for treating dysentery and hernia [7, 8]. In addition, *Irvingia gabonensis* seeds contain a sticky wax (mucilage) that is useful for making medicinal tablets. This wax acts as a binding agent during the production of drug tablets. Studies have revealed that tablets manufactured with *Irvingia gabonensis* seeds have increased brittleness and reduced tensile strength when compared with gelatin tablets. The extract of the seed of *Irvingia gabonensis* fruit can also be used for medicinal purposes. The powdered kernels of *Irvingia gabonensis* seeds can be used as an astringent applied to the skin to soothe burns and reduce bleeding from minor abrasions [9], and treat wounds [10]. Aqueous and ethanol extracts of *Irvingia gabonensis* seeds have been reported to improve renal and hepatic functions [11, 12].

There is paucity in scientific literatures on the

physicochemical properties of these useful plant products. This research was therefore conducted to elucidate the physicochemical properties and fatty acid profile of *Irvingia gabonensis* (Kuwing) seed which will also enhance its industrial applications.

2. Materials and methods

2.1 Identification and collection of sample

Irvingia gabonensis tree was identified in the University of Calabar farm by a Botanist, Dr. Mike Eyo of the Department of Botany, University of Calabar, Nigeria. Fresh fruits from the tree were carefully plucked.

2.2 Oil extraction

The *Irvingia gabonensis* seeds were obtained from the fruits. The seeds were ground to powdery form using a manual grinder. The powder obtained underwent analytical grade ethanol extract. This extraction yielded a crude black extract. The crude black extract later underwent exhaustive soxhlet extraction with analytical grade n-hexane to yield a golden-yellow oil fraction. Standard methods were used for the analysis of the physicochemical properties and fatty acid profile of the oil.

2.3 Analysis of physicochemical properties

The physicochemical indices [acid value (AV), iodine value (IV), peroxide value (PV) saponification value (SV), specific gravity (SG), refractive index (RI), relative density (RD), melting point (MP), flash point (FLP), smoke point (SMP), freezing point (FRP), setting point (STP) and pH] were carried out according to the methods described by AOAC [13].

The fatty acid profile of Kuwing seed oil was determined by gas liquid chromatography (Hewlett Packard, model 5750).

Specific gravity was done using specific gravity bottle. Refractive index was characterised using Abbe refractometer. Flash point was analysed using the semiautomatic Cleveland flash point tester [14]. The oven dry method was used to characterized the moisture content (MI) and a Hanna pH meter (model no: 02895) was used to determine the pH. Titrimetry, according to FAO [15] was used to determine iodine, acid and peroxide values. Percentage free fatty acid (%FFA) (as oleic) was determined by the multiplication of the acid value by the factor 0.503. Thus, % FFA = Acid value × 0.503 [16]. Saponification values were determined by titrimetry using the methods of the Palm Oil Research Institute of Malaysia [17]. All analyses utilised analytical-grade reagents.

2.4 Fatty acid analysis

The homogenized sample was stored at -20°C until analysed. After an acid hydrolysis using 4 N hydrochloric acid (Sigma Aldrich, Germany), total fat content was extracted in a SOXTHERM 2000 S306 Automatic Extractor System Gerhardt (Gerhardt; Bonn, Germany) with 140ml of petroleum ether (Sigma Aldrich, Germany; extraction time: 30 min; temperature: 150°C). Lipids for Fatty acid analysis were extracted according to Folch *et al.* [18]. The lipid extract was stored at -20°C. Total lipids (25 mg) were saponified with a 0.5 M methanolic sodium hydroxide solution at 100°C (10 min). The subsequent methylation of fatty acids to fatty acid methyl esters was performed using methanolic boron trifluoride (BF_3) solution (10% w/w, Sigma Aldrich, Germany) at 100°C for 5 min [19].

The fatty acid methyl esters were analysed by gas chromatography (GC) (GC-17A; Shimadzu, Kyoto, Japan) using a 60m fused-silica capillary column of medium polarity (DB 225MS: 60m × 0.25mm i.d. with 0.25mm film thickness; Agilent Technologies, USA). Conditions for GC analysis and peak integration as well as the standards used have been previously described [20].

2.5 Statistical Analysis

Results are presented as mean ± standard error of mean (SEM) of four determinants. Microsoft Excel was used to compute the mean values and SEM.

3. Results & Discussion

Table 1 shows that Kuwing seed oil is light yellow in colour, yielded 67.33±1.2, with a pH of 6.32 ±0.07 and a specific gravity of 0.85±0.03kg/dm^3. Specific gravity of 0.93 kg/dm^3 has been reported of Egusi seed oil [21] indicating that it is less dense than water. Relative density of 0.82±0.01 was recorded of Kuwing seed oil. The refractive index was 1.37 ±0.01. This is lower compared to 1.45 obtained for Egusi seed oil, 1.46 for *B.sapida* [22] oil, and 1.48 to 1.49 for most drying oils [21]. This shows that the Kuwing seed oil is less thick compared to most other oils. Refractive index of a fat is the ratio of speed of light at a defined wavelength to its speed in the fat itself. This value varies with wavelength and temperature, the degree and type of unsaturation, the type of substitutions of component fatty acids and with accompanying substances. Refractive index is widely used in quality control to check for the purity of materials and to follow hydrogenation and isomerization. This value fell within acceptable range of 1.4677 to 1.4707 for virgin, refined and refined-pomace oils according to Codex Standards for fats and oils from vegetable sources [23].

Table 1: Physicochemical properties of *Irvingia gabonensis* (Kuwing) seed oil

Physicochemical property	Composition
Specific Gravity(kg/dm^3)	0.85±0.03
Relative Density	0.82±0.01
Refractive index	1.37±0.01
Melting point (ºC)	13.34±0.01
Setting point (ºC)	24.65±2.68
Smoke point (ºC)	77.20±1.91
Flash point (ºC)	120.03±0.50
Freezing point (ºC)	165.97±0.30
pH	6.32±0.07
Acid value (mgKOH g^{-1} oil)	11.35±0.03
Saponification value (mg KOH g^{-1})	181.9±0.21
% unsaponifiable	1.51±0.01%
Iodine value (mg iodine g^{-1})	4.18±0.02
Peroxide value (meq/kg)	2.67±0.03
Yield (%)	67.33±1.20
Moisture index (%)	5.31±0.01
Colour	Light yellow
Aflatoxin	0.00±0.00
% free fatty acid	7.37±0.12%

Values are mean ± standard error of mean (SEM) of four determinants

The acid value of 11.35±0.03 mgKOH g-[1] of oil was recorded. This value is higher than values obtained for most edible oils like Egusi seed oil (3.5±0.3 mgKOH g^{-1}), tropical almond (7.6 mgKOH g-[1]) and fluted pumpkin (3.5 mgKOH g^{-1}) [24]. Low acid value of oil indicates that the oil is good as edible oil. Acid values accounted for the presence of free fatty acids in the oil as an indicator of the presence and extent of hydrolysis by lipolytic enzymes and oxidation [25]. The higher value indicates that the oil will be unstable over a long period of time and would not protect against rancidity and peroxidation.

The iodine value of Kuwing seed oil was 4.18±0.02 mg iodine g^{-1}. This is similar to that of coconut oil (6.0-10.0) which is a saturated fatty acid-rich oil, but lower compared to that of most unsaturated fatty acid-rich oil like melon seed oil (110.0±8.2), peanut (86.0-107.0), cottonseed (100.0-123.0), sesame (104.0-120.0), sunflower (118.0-141.0) and soybean oil (124.0-139.0) [26]. Also, lower than those of most saturated fatty acid-rich oils such as *Theobroma cacao*, cocoa butter (32.0-42.0) [27], palm oil (50.0-55.0), palm kernel (14.0-1.0) [26]. This result of iodine value indicates that *Irvingia gabonesis* has primarily saturated fatty acids. Iodine number of oil is a measure of its unsaturation and is a useful criterion for purity and identification. The relatively low iodine value of the kuwing seed oil seen in this study may be an indication of the presence of few unsaturated bonds and low susceptibility to oxidative rancidity.

Kuwing seed oil has a peroxide value of 2.67±0.03 meq/kg. This value is lower than values obtained for must seed oil like Egusi melon oil (8.3±4.6), Bauchinia racemora (4.9) seed [28]. Peroxide value depends on a number of factors such as the state of oxidation (quantity of oxygen consumed), the method of extraction used and the type of fatty acids present in the oil. The low peroxide value of Kuwing seed oil shows less lipid oxidation. Absorption of oxygen increases the formation of peroxides [29]. Polyunsaturated fatty acids easily undergo oxidation, raising peroxide value of oils. The low peroxide value of the oil in this study is indicative of low level of oxidative rancidity of the oil and also suggests the presence for high level of antioxidant. This shows that Kuwing seed oil is good for consumption.

The saponification value of Kuwing seed oil was 181.9±0.21 mg KOH g^{-1}. This agrees with values obtained for Egusi oil, 192.0±43.7 and some vegetable oils ranging from 188-196 mg KOH g^{-1} [30]. However, there are some vegetable oils with higher saponification values such as coconut oil (253.0 mg KOH g^{-1}), palm kernel oil (247.0 mg KOH g^{-1}) and butter fat (225.0 mg KOH g^{-1}) [26]. Oil with higher saponification values contains high proportion of lower fatty acids. Therefore, Kuwing seed oil contains more of the lower fatty acids. An increase in the volatility of oil occurs following an increase in saponification value (SV). Increased SV enhances the oil quality because it shows the presence of lower molecular weight components in 1g of the oil. SV is the number of milligrams of potassium hydroxide required to neutralize the fatty acids liberated on complete hydrolysis or saponification of 1g of the oil. It relates inversely with the molecular weight of the oil since 1g of oil or fat containing low molecular weight fatty acids will have more molecules than oil or fat containing higher molecular weight fatty acids [31]. The unsaponifiable matter was 1.51±0.01%. Most oils and fats of normal purity contain less than 2% of unsaponifiable matter.

The melting point of Kuwing seed oil was 13.34 ±0.01ºC, the smoke point 77.2 ±1.91 ºC, and the freezing point, 165.97 ±0.30 ºC. The flash point was 120.03 ±0.50. Smoke point of a fatty material is measure of its thermal stability when heated in contact with the air. Fatty acids are much less stable than glycerides, hence the smoke points of ordinary oils depend principally upon their content of free fatty acids. Melting point decrease with increase in the degree of unsaturation. Therefore, the lower melting point oils are probably useful in the manufacture of soft and easy-to- digest margarine and are of much value in the manufacture of oil creams. The percentage free fatty acid content was 7.37 ±0.12%.

No aflatoxins were recorded in the oil of Kuwing seed, showing that it is free of toxins.

Table 2 shows the fatty acid composition of kuwing seed oil. The following percentages of fatty acid were found: caproic acid (0.55±0.05), caprylic acid (0.07±0.00), capric acid (1.6±0.1), lauric acid (40.5±0.2), myristic acid (42.75±0.25), palmitic acid (4.7±0.1), stearic acid (0.85±0.05), oleic acid (4.5±0.1), erucic acid (0.06±0.01), linoleic acid (0.65±0.05), alpha-linoleic acid (4.2±0.1) and arachidonic acid (0.14±0.00).

Table 2: Fatty acid composition of *Irvingia gabonensis* (Kuwing) seed oil

Fatty Acid	% Composition
Caproic	0.55±0.05
Caprylic	0.07±0.00
Capric	1.6±0.1
Lauric	40.5±0.2
Myristic	42.75±0.25
Palmitic	4.7±0.1
Stearic	0.85±0.05
Oleic	4.5±0.1
Erucic	0.06±0.01
Linoleic	0.65±0.05
Alpha-linolenic	4.2±0.1
Arachidonic	0.14±0.00

Values are mean ± standard error of mean (SEM) of four determinants

From these results, myristic acid was the most abundant followed by lauric acid. This implies that kuwing seed oil can be regarded as myristic-lauric oil. These results are in tandem with the report of Matos *et al.* [32] but contradict the report of Etong *et al.* [33] where lauric acid was reported to be the most abundant in *Irvingia gabonensis* seed oil followed by myristic acid.

4. Conclusions

The present study indicates that *Irvingia gabonensis* (Kuwing) seed oil is saturated and a good source of myristic acid and lauric acid. The oil is therefore of good quality and can be used for domestic and industrial purposes.

5. References

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