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PHYSICOCHEMICAL PROPERTIES AND FATTY ACID PROFILES OF OILS FROM *BLIGHIA SAPIDA* ARIL, *DACRYODES EDULIS* PULP, AND *CYPERUS ESCULENTUS* TUBERS

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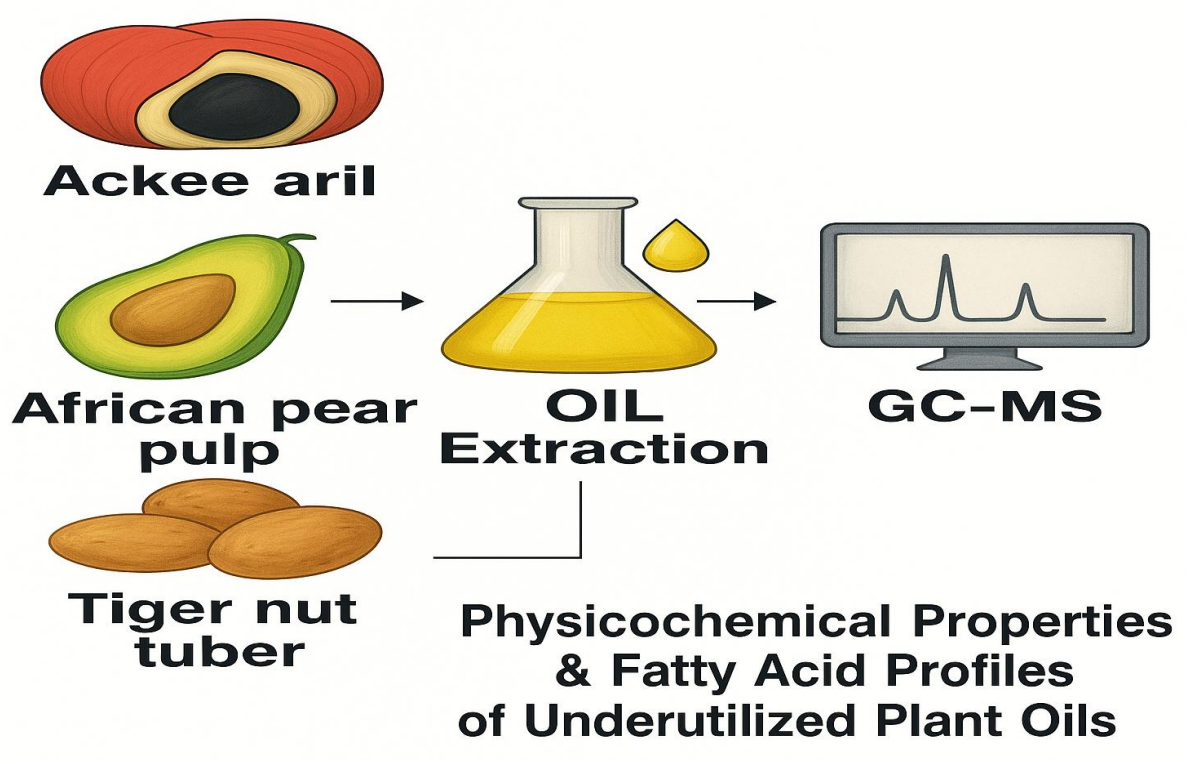
Abstract

This study assessed the physicochemical properties and fatty acid composition of oils extracted from *Blighia sapida* aril, *Dacryodes edulis* pulp, and *Cyperus esculentus* tubers to determine their nutritional and industrial potentials using AOAC standard analytical techniques. Oil yields ranged from 18.44% (*C. esculentus*) to 40.35% (*B. sapida*). Specific gravities (0.85–0.96 g/cm³) and refractive indices (1.45–1.47) were within Codex standards for edible oils. Acid values varied from 0.92 to 5.02 mg KOH/g, iodine values from 60.24 to 120.54 mg I_2/g, peroxide values from 0.90 to 4.93 mEq/kg, and saponification values from 177.87 to 207.38 mg KOH/g, reflecting differences in quality, stability, and level of unsaturation. Gas Chromatography Mass Spectrometry revealed distinct fatty acid profiles: *B. sapida* oil was highly saturated (93.46%) dominated by hexadecanoic acid (72.68%) as the major component; *D. edulis* oil contained a balance of saturated (59.38%) and unsaturated (39.30%) fatty acids, primarily n-hexadecanoic acid (45.60%) and oleic acid (35.26%). Meanwhile *C. esculentus* oil was rich in unsaturated fatty acids (65.91%), with oleic acid (33.74%) as the most abundant. The findings indicate that *B. sapida* oil is suitable for thermal and storage stability, *D. edulis* oil offers nutritional and cosmetic benefits due to its high oleic acid content, and *C. esculentus* oil has potential applications in both nutrition and biodiesel production. These results highlight the potential nutritional and industrial applications of the oils.

***Keywords:** Blighia sapida, Dacryodes edulis, Cyperus esculentus, Physicochemical properties, Fatty acid composition.*

Graphical Abstract



1.0 INTRODUCTION

The oils extracted from Blighia sapida aril, Dacryodes edulis pulp, and Cyperus esculentus tubers are gaining interest for their nutritional, cosmetic, and industrial applications. While they are from different plant sources, they share some common characteristics as edible oils. They are important in the development of different products such as pharmaceuticals, cosmetics and paints [1]. Vegetable oils are triglycerides of plant origin with chains of fatty acids containing about 14–20 carbon atoms with different degrees of unsaturation [2]. They are obtained from seeds, fruits, or nuts by different pressing methods, solvent extraction, or a combination of these methods [3]. Some of the commonly known vegetable oils include canola, palm, olive, soybean, sunflower and peanut oil. Other less common ones, include Almond, Rice bran, Niger seed and Safflower oil. With the development of agriculture processing and inspection technologies, more plants are being exploited for edible vegetable oil [4].

Oils are important nutritional components with a variety of functions in our body including being part of membrane structures, regulating body temperature and insulation of organs. They play a role in carrying fat-soluble vitamins and serve as a source of energy and essential fatty acids vital for development [5]. Their compositions in addition to their physical and chemical properties determine their usefulness in various applications aside from edible uses. A large percentage of the world's oils and fats come from plant sources [6]. Oils are a major component of the human diet, comprising about one-third of our calorie intake [7].

Dacryodes edulis is an oliferous specie of fruit trees belonging to the Burseraceae family and is native to the humid low lands and plateau regions of West, Central African and Gulf of Guinea countries which include Cameroon, Nigeria, Angola, Uganda and Zimbabwe [8]. The tree grows to a height of 12–57 m with feathery like shiny leaves, ellipsoidal fruit of about 4 to 9 cm long with a width of 2–5 cm. The outer covering of the fruit has a violet or dark blue colour, whereas the pulp is light to pale green [9]. It is an annual fruit commonly known as African plum or African pear which is one of the under-utilized seed. They are cultivated around households and begins to flower usually from January to April and fruiting between May and October [10].

In Nigeria the African pear is locally referred to as 'Ube' in Igbo, 'Elemi' in Yoruba and 'Atili' in Hausa languages. The fruit is made up of a pulpy pericarp that encloses a seed coat which contains the seed. The pulp is softened by either soaking in warm salt water, hot ash, or grilled in an oven and often eaten alone or with cassava, plantain and roasted or boiled maize [11]. The fruit pulp is acknowledged for its rich protein, fat, fibre, minerals and essential amino acids constituents. It can be a source of vegetable oil with

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the pulp reported to contain considerable amounts of oil up to 48 % [12].

Blighia Sapida belongs to the family *Sapindaceae,* a woody perennial, evergreen tree. Its botanical classification is as follows: Kingdom: Plantae, Specie: *Blighia sapida,* Clade: Angiosperms, Order: Sapindales, Family: Sapindaceae, Genus: *Blighia*, [13]. The fruit is commonly referred to as 'Ackee' in English, 'Yila' in Nupe, 'Gwanju Kusa' in Hausa, 'Isin' in Yoruba and 'Okpu' in Igbo [14]. The fruits are red when matured and splits open with continued exposure to the sun revealing a thick fleshy stalk, rich in oil [15]. The ripe edible arils are usually yellow to cream coloured with shiny black and smooth seeds. The plant has January to March and June to August as two peak fruiting seasons. The ripe arils are eaten fresh, roasted, fried or used in making soup [16]. Ripe blended arils are mixed with sugar and administered in the treatment of fever and dysentery while a mixture of the bark and other pungent species is applied as an ointment to relieve pain. Aqueous extract of the seed is administered to expel parasite and the crushed foliage is used to reduce severe headache when applied on the fore head [17].

Cyperus esculentus commonly called tiger nut is a perennial plant belonging to the family *Cyperaceae*. It produces
stolons, rhizomes and tubers that are spherical in shape. The plant is usually 15–60 cm tall, glabrous and light green in colour. The tubers are white when young and yellow when they mature; the matured tubers are covered with an outer membrane. They generally grow about six inches from the surface of the ground with clonal colonies frequently produced from the rhizomes and tubers [18].
The plant is believed to be native to Egypt but is also widely distributed in the temperate regions of Southern Europe and West Africa including Ghana, Sierra Leone and Nigeria. Other names it is known by include; Ground almond, yellow nut grass, Zulu nuts and Chufa. In Nigeria, it is commonly known as 'Aya' in Hausa, 'Imumu' in Yoruba, and 'Ofio' in Igbo [19]. Tiger nut grows favorably in well drained sandy or loamy soils and its yield increases with an increase in ambient temperature, maturing in about 90 - 110 days between April and November. It is easily cultivated and does not necessarily require additional fertilizers for growth and increased yield [20].
Tiger nut is an underutilized plant with three well known varieties (yellow, brown and black) commonly cultivated. The yellow and brown species are widely available in the market with the yellow variety more popular due to its characteristic properties which include; an attractive colour, fleshier body and larger size. Tiger nut contains rich amounts of starch, fat, sugars and protein. It also contains minerals such as phosphorus, potassium and vitamins E and C [18]. Its consumption has been reported to help in preventing heart diseases, thrombosis and improves blood circulation. The high soluble glucose content helps in preventing cancer and is also suitable for diabetic persons and weight loss [21].

Figure 1: Dried *Dacryodes edulis* pulp (Field work)

Figure 2: *Cyperus esculentus* (Field work)

Figure 3: ***Blighia sapida*** **aril (Field work)**

Fatty acids are fundamental biomolecules that serve as critical sources of energy and important components of cellular membranes. These molecules are made up of diverse classes including saturated, monounsaturated, and polyunsaturated fatty acids (PUFAs), each with its biological functions. Omega-3 and omega-6 fatty acids which are essential fatty acids gotten from diet are known to contribute to neurodevelopment, demonstrate anti-inflammatory and cardioprotective effects and are also involved immune responses and cell growth [22]. Overall, the biological roles of fatty acids extend broadly across health and disease, underlining their importance in both fundamental physiology and nutrition [23].
Globally, natural vegetable oils and fats are increasingly becoming important in nutrition and

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commerce because they are good sources of dietary energy, antioxidants, and bio-fuels. They are useful raw materials for the manufacture of industrial products with millions of tonnes produced annually [6]. They are used in foods, cosmetics, pharmaceutical and chemical industries. Vegetable oils in Nigeria are produced locally and also imported, an indication of the important roles it plays. Attention is now being shifted towards the use of underutilized plants as alternative to the commercially available oils in the market. Despite of the availability of *Blighia sapida*, *Dacryodes edulis*, and *Cyperus esculentus* in Nigeria, their oils remain largely underexploited compared to conventional oils such as palm, groundnut, and soybean. This has limited their utilization in food, health and industrial applications, despite their potential as alternative and sustainable oil sources.
Thus, this research work focused on analysing the physicochemical properties and fatty acid composition of oils from these underutilized plants in order to ascertain their suitability for edible and industrial purposes.

2.0 MATERIALS AND METHODS

2.1 Samples and Sampling

Cyperus esculentus tubers were purchased from new market in Bida, Nigeria. Fruits of *Blighia sapida* were harvested from trees in Doko while *Dacryodes edulis* fruit was harvested from trees in Kutigi all in Nigeria. The identification of the samples was carried out at the Department of Plant Biology, Federal University of Technology, Minna, Nigeria.

2.2 Sample Pre-treatment

The tubers of *Cyperus esculentus*, pulps of *Blighia sapida*, and *Dacryodes edulis* were separated from other components of the fruit and screened for bad ones. They were washed with clean water and sundried for two (2) weeks after which they were pulverized using a mechanical blender (Buchymix BX210), sieved with a 250 µm sieve to obtain fine homogenous samples, then kept in air-tight containers for storage until further analysis.

2.3 Extraction of Oils from the Selected Plants

Oil was extracted from each powdered sample (100 g) using a Soxhlet apparatus with n-hexane (analytical grade, Sigma-Aldrich) as the solvent. The extraction was conducted for 3 hours at a temperature of 60 °C. A rotary evaporator (Buchi R-300) was used to remove the solvent from the oil–solvent mixture at 40 °C. The extracted oil was dried in a vacuum oven at 60 °C for 15 minutes to remove any residual solvent. Percentage yield (PY) was calculated gravimetrically. Each extraction was performed in triplicate. [24].

$$PY = \frac{Weight\ of\ oil\ extract\ (g)}{Weight\ of\ sample\ (g)} \times 100 \qquad (1)$$

2.4 Preparation of Fatty Acid Methyl Esters (FAME) Derivatives

Fatty acid methyl esters were prepared according to the standard method 2.301 (IUPAC) with slight modifications. Briefly, 0.2 g of oil was dissolved in 6 cm^3 of 0.5 M methanolic NaOH and refluxed at 80 °C for 10 minutes to saponify the triglycerides. Subsequently, 10 cm^3 of a 2:3 (v/v) mixture of concentrated HCl and methanol was added and the mixture refluxed for a further 10 minutes to esterify the fatty acids. After cooling, 10 cm^3 of n-hexane (HPLC grade) was added, and the mixture refluxed for 2 minutes to extract the FAMEs into the organic phase, after which it was transferred to a separation funnel, and the hexane layer collected. The FAME extract was washed with 10 cm^3 of distilled water and dried over anhydrous sodium sulfate. Filtration and concentration of the solution was carried out under a gentle stream of nitrogen before the GC-MS analysis. [25].

2.5 Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

FAME analysis was carried out by an Agilent 8890 GC gas chromatograph coupled with a MS Model, Agilent 5977B mass selective detector. Separation was achieved on a Column, SP-2560, 100 m × 0.25 mm i.d. × 0.20 µm film thickness fused silica capillary column. The temperature program of the oven was: initial temperature 45 °C (hold 4 min), ramped to 175 °C at 13 °C/min (hold 27 min), then increased to 215 °C at 4 °C/min (hold 35 min). The injector and transfer line temperatures were set at 250 °C and 240 °C, respectively. Helium was used as the carrier gas at a constant flow rate of 1.0 mL/min. 1 µL of the samples were introduced into split mode (split ratio 50:1). The mass spectrometer was run in electron impact (EI) mode at 70 eV, with a scan range of *m/z* 50–550. Fatty acids were identified by comparing retention times and mass spectra of the generated peaks to those of authentic standards from a Supelco 37-component FAME mix. [25].

2.6 Determination of Specific Gravity (SG)

Specific gravity of each oil sample was performed in triplicate at 25 °C using a 25 cm^3 pycnometer according to the American Oil Chemists' Society (AOCS) Official Method Cc 10a-25. A clean, dry pycnometer was weighed empty (W_0). It was then filled with the oil sample, equilibrated to 25 °C in a temperature-controlled water bath, stoppered, and weighed (W_1). The oil sample was removed, and the pycnometer was cleaned, dried, and filled with distilled water at 25 °C and weighed again (W_2). The formula below was used to calculate the specific gravity:

$$Specific\ gravity = \frac{W_1 - W_2}{W_2 - W_0} \times 100 \qquad (2)$$

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Where W_0 = weight of the empty pycnometer, W_1 = weight of the pycnometer + oil, W_2 = weight of the pycnometer + water. [24].

2.7 Determination of Refractive index (RI)

The refractive index of the oil samples was measured in triplicate at 40 °C using an Abbe refractometer (Atago RX-5000α) calibrated with distilled water. Few drops of each oil sample were placed on the dry prism assembly, and the reading taken once the temperature had stabilized. The mean value of three independent readings was recorded for each sample, as per AOCS Official Method Cc 7-25 [26].

2.8 Determination of Peroxide value (PV)

The peroxide value (PV), which is expressed as milliequivalents of active oxygen per kilogram of oil (mEq/kg), was performed in triplicate according to AOCS Official Method Cd 8b-90. Briefly, 1.00 g of oil sample was dissolved in 20 cm^3 of an acetic acid and chloroform solution (3:2 v/v). 1.0 cm^3 of a solution of saturated potassium iodide (KI) was added, and the mixture swirled for 1 minute before adding 30 cm^3 of distilled water. Titration of the liberated iodine was done with a standardized solution of 0.01 N sodium thiosulfate ($Na_2S_2O_3$) using starch as indicator. A blank determination was conducted simultaneously. The formula below was used to calculate the peroxide value [24]

$$Peroxide\ value = \frac{S - B \times N \times 100}{W} \quad (3)$$

Where, S= Volume of $Na_2S_2O_3$ used for the sample (cm^3), B= Volume of $Na_2S_2O_3$ used for the blank (cm^3), N= normality of the $Na_2S_2O_3$ solution and W= The sample weight (g).

2.9 Determination of Acid value (AV)

The acid value (AV), expressed as milligram of potassium hydroxide (KOH) required to neutralize the free fatty acids in a gram of oil (mg KOH/g), was determined in triplicate according to AOCS Official Method Cd 3d-63. 25 cm^3 of a neutralized diethyl ether-ethanol mixture (1:1 v/v) was used to dissolve 2.00 g of oil. The solution was titrated with a standardized 0.1 M potassium hydroxide (KOH) solution with phenolphthalein as an indicator until a faint pink colour persisted for at least 30 seconds. The formula below was used to calculate the acid value:

$$Acid\ value = \frac{V \times M \times 56.1}{W} \quad (4)$$

Where V = Volume of KOH solution used (cm^3), M = Molarity of the KOH solution, 56.1= Molecular weight of KOH, and W = The sample weight (g). [26].

2.10 Determination of Iodine value (IV)

The iodine value (IV), expressed as grams of iodine absorbed per 100 g of oil (g I_2/100g), was determined in triplicate according to AOCS Official Method Cd 1-25 (Wijs method). 10 cm^3 of carbon tetrachloride was used to dissolve 0.30 g of oil. 25.0 cm^3 of Wijs solution was added, the flask was stoppered, and the mixture stored in the dark for 1 hour. After the reaction period, 20 cm^3 of a 15% potassium iodide (KI) solution and distilled water (100 cm^3) were added. A standardized 0.1 N sodium thiosulfate ($Na_2S_2O_3$) solution was used to titrate the liberated iodine with constant shaking, using starch as an indicator. A blank titration was performed simultaneously. The iodine value was calculated using the formula:

$$Iodine\ value = \frac{(B - S) \times N \times 12.69}{W} \quad (5)$$

Where, B = Volume of $Na_2S_2O_3$ used for the blank (cm^3), S = Volume of $Na_2S_2O_3$ used for the sample (cm^3), N = Normality of the $Na_2S_2O_3$ solution, 12.69 is the conversion factor (1.269 × 10, accounting for the atomic weight of iodine and the 100g basis), W = The sample weight (g) [26].

2.11 Determination of Saponification Value (SV)

The saponification value (SV) was determined according to AOAC Official Method 920.160/920.161. Exactly 2.0 g of oil sample was weighed into a flask and 25.0 cm^3 of 0.5 N alcoholic potassium hydroxide (KOH) solution was added. The flask was fitted with a reflux condenser and heated on a temperature-controlled water bath for 30 minutes with regular shaking at interval to allow for complete saponification. After reflux, the hot solution was titrated with standardized 0.5 N hydrochloric acid (HCl) with phenolphthalein used as an indicator until the pink color disappeared. A blank determination was carried out under the same conditions without the oil sample. The equation below was used to calculate the saponification value (SV):

$$SV = \frac{(B - S) \times N \times 56.1}{W} \times 100 \quad (6)$$

where B= volume of HCl used for the blank (cm^3), S= volume of HCl used for the sample (cm^3), M= normality of HCl, 56.1 = molar mass of KOH (g/mol) × 1000 (mg/g) and W= weight of oil sample (g) [24].

2.12 Statistical Analysis

All experiments were conducted in triplicate. Data are presented as mean ± standard deviation. Statistical analysis was performed using SPSS Statistics software (version 20; IBM Corp.). One-way analysis of variance (ANOVA) followed by Duncan's multiple range test was employed to determine significant difference between sample means. A probability value of $p \leq 0.05$ was considered statistically significant.

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3.0 RESULTS AND DISCUSSION

3.1 Physicochemical parameters

Table 1: Physicochemical Parameters of Selected Oils

Parameter	*Blighia sapida*	*Dacryodes edulis*	*Cyperus esculentus*
Yield (%)	40.35	36.57	18.44
Specific gravity(g/cm^3)	0.85 ± 0.01^a	0.88 ± 0.01^b	0.96 ± 0.01^c
Refractive Index	1.45	1.47	1.46
Acid value (mg KOH/g)	5.02 ± 0.19^a	2.87 ± 0.11^b	0.92 ± 0.04^c
Iodine value (mg I_2/g)	90.38 ± 1.18^b	60.24 ± 0.56^c	120.54 ± 1.56^a
Peroxide value (mEq/kg)	4.93 ± 0.40^a	0.90 ± 0.05^c	1.04 ± 0.24^b
Saponification value (mgKOH/g)	190.97 ± 2.64^b	207.38 ± 5.40^a	177.87 ± 2.99^c

The oil yield obtained for *Blighia sapida* (40.35 %) was the highest, followed by *Dacryodes edulis* (36.57 %) and *Cyperus esculentus* (18.44 %). These values indicate that both *B. sapida* and *D. edulis* are rich sources of oil, comparable to other tropical oil-bearing seeds such as palm kernel (36–46 %) and groundnut (40–50 %) [27]. In contrast, the yield of *C. esculentus* (tigernut) was relatively low, consistent with earlier reports of 17–22% depending on extraction method [30]. Yield differences are largely influenced by species, genotype, maturity stage, and extraction conditions [28]. *Blighia sapida* and *Dacryodes edulis* exhibited high oil yields comparable to conventional oil crops, indicating their potential as alternative edible and industrial oil sources, while *Cyperus esculentus* showed lower yield but is valuable for specialized nutritional applications due to its composition.

The specific gravities ranged between 0.85–0.96 g/cm³. *B. sapida* oil had the lowest (0.85), followed by *D. edulis* (0.88) while *C. esculentus* recorded the highest (0.96). These values fall within the range for edible oils (0.89–0.92 g/cm³) [29]. The specific gravities are in the range of 0.74-0.97g/cm^3 reported for selected underutilized seeds by [30]. The specific gravities of the oils were within the acceptable range for edible oils, confirming their suitability for consumption, with slight differences an indication of the variations in fatty acid composition.

The refractive indices ranged between 1.45 and 1.47. These values are within the acceptable range of 1.44–1.48 reported for most edible oils [31]. The slight variations reflect differences in degree of unsaturation, as oils with higher unsaturation generally exhibit higher refractive indices. The value for *D. edulis* (1.47) suggests a higher content of unsaturated fatty acids compared to *B. sapida*.

Acid value represents the measure of free fatty acids (FFA), reflecting oil hydrolysis and susceptibility to rancidity. *B. sapida* recorded the highest acid value (5.02 mg KOH/g), followed by *D. edulis* (2.87 mg KOH/g) and *C. esculentus* (0.92 mg KOH/g). According to Codex Alimentarius standards, the maximum recommended limit for crude vegetable oils is 4.0 mg KOH/g, while refined oils should not exceed 0.6 mg KOH/g [32]. [10] reported values of 3.2 and 4.7 mgKOH/g for ackee aril. [33] reported 1.22, 0.75, 2.72 mgKOH/g for C. *schweinfurthii, B. aegyptiaca* and *S. indicum* oils. *B. sapida* oil exceeded the crude oil limit, suggesting higher susceptibility to deterioration, while *C. esculentus* oil indicate a more stable quality.

Iodine value reflects the extent of unsaturation. *C. esculentus* had the highest Iodine value (120.54 mg I_2/g), followed by *B. sapida* (90.38 mg I_2/g) and *D. edulis* (60.24 mg I_2/g). Iodine value ranges for edible oils: soybean oil (120–143), palm oil (44–56), groundnut oil (82–107) [37]. [34] reported values of 31.0, 96.4 and 129.5 mg I_2/g for Hayat, Sunflower and Niger seed oils. *C. esculentus* oil falls within the category of highly unsaturated oils, making it nutritionally desirable but less stable to oxidation. *D. edulis* showed the lowest Iodine value, confirming its predominance in saturated fatty acids as reported by [35].

The peroxide value is an index of determining rancidity in oils; thus, a high peroxide value of oil indicates a poor resistance of the oil to peroxidation during storage [36]. *B. sapida* had the highest Peroxide value (4.93 mEq/kg), while *D. edulis* (0.90 mEq/kg) and *C. esculentus* (1.04 mEq/kg) were considerably lower. Peroxide values of 1.46, 6.32 and 6.53 were reported for sunflower, avocado and safflower oils [37]. FAO/WHO recommends that Peroxide value for edible oils should not exceed 10 mEq/kg [38]. Hence, all oils in this study were within acceptable limits. The relatively higher Peroxide value in *B. sapida* indicates it may be more prone to oxidative rancidity compared to the other oils.

Saponification values for this study were 177.87 mg KOH/g, 190.97 mg KOH/g and 207.38 mg KOH/g for *C. esculentus*, *B. sapida* and *D. edulis* respectively. These values fall within the general range of 180–250 mg KOH/g typical for edible oils [39]. The values are lower than the 223.7 mg KOH/g reported for *Nigrescens* by [40]. [41] reported 156 mgKOH/g for *Khaya senegalensis* oil while [42] reported 199.71 mgKOH/g for Mahogany seed oil. A

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higher SV is an indication of the presence of shorter-chain fatty acids. *D. edulis* oil may contain more medium-chain fatty acids, making it useful for soap and cosmetic industries. Equally, *C. esculentus oil* with lower saponification value suggests a dominance of longer-chain fatty acids, consistent with its reported fatty acid profile rich in oleic acid [43].

3.2 Fatty Acid Composition of the Oil Extracts

Gas Chromatography-Mass Spectrometry (GC-MS) was used to analyze the fatty acid profile of the oil extracts of *Blighia sapida* aril, *Dacrodes edulis* pulp and *Cyperus esculentus* tuber. The results presented in Table 2-4 showed variations in unsaturated fatty acids (UFA), saturated fatty acids (SFA) and fatty acid esters (FAME, FAEE).

Table 2: Fatty Acids Composition of *Blighia sapida* Aril Oil Extract

Compound	Molecular weight	Molar mass (g/mol)	Retention time	Area (%)	Classification	Total (%)
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	16.313	6.57	SFA	SFA= 93.46
Eicosanoic acid	$C_{20}H_{40}O_2$	312	17.099	3.40	SFA	UFA= 3.35
Oleic acid	$C_{18}H_{34}O_2$	282	17.390	2.38	UFA	FAME=2.91
9-Octadecenoic acid (z)-	$C_{18}H_{34}O_2$	282	18.272	0.97	UFA	FAEE= 0.25
Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	18.579	2.44	FAME	PT= 99.97
Hexadecanoic acid	$C_{16}H_{32}O_2$	256	19.224	72.68	SFA	
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	19.545	0.25	FAEE	
11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	20.990	0.24	FAME	
Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298	21.232	0.23	FAME	
Octadecanoic acid	$C_{18}H_{36}O_2$	284	21.697	10.81	SFA	

SFA= Saturated fatty acid, UFA= Unsaturated fatty acid, FAME= Fatty acid methyl ester, FAEE= Fatty acid ethyl ester, PT= Percentage total

A total of ten fatty acid-related compounds were identified, comprising unsaturated fatty acids (UFA), saturated fatty acids (SFA), fatty acid methyl esters (FAME) and fatty acid ethyl esters (FAEE).

The most abundant compound was Hexadecanoic acid which made up 72.68 % of the total fatty acid content. This was followed by Octadecanoic acid at 10.81 %, Tetradecanoic acid at 6.57 % and Eicosanoic acid at 3.40 %. Collectively, these saturated fatty acids contributed to a remarkably high total SFA content of 93.46 %, signifying that the oil is largely saturated. The dominance of saturated fatty acids in *Blighia sapida* aril oil makes it inherently more resistant to oxidation and rancidity during storage due to the absence of double bonds, compared to oils rich in polyunsaturated fatty acids. Oils rich in saturated fatty acids tend to exhibit longer shelf life and greater thermal stability [44]. The unsaturated fatty acids (UFAs) were found in much smaller proportions. Oleic acid (2.38 %) and 9-octadecenoic acid (0.97 %) were detected in minor amounts bringing the total UFA content to 3.35 %. Oleic acid is a common monounsaturated fat in human diet and has been associated with decreased low-density lipoprotein (LDL) cholesterol. Although the UFA content is relatively low, the presence of oleic acid enhances the nutritional value of the oil [45].

Fatty acid esters, including methyl and ethyl esters such as hexadecanoic acid methyl ester (2.44 %), hexadecanoic acid ethyl ester (0.25 %), 11-octadecenoic acid methyl ester (0.24 %), and octadecanoic acid methyl ester (0.23 %) were reported with a total percentage area of 2.91 %. These esters are typically introduced during sample preparation for GC-MS analysis through derivatisation processes like methylation [46]. Previous studies by [47] and [48] reported high saturated fatty acid compositions of 91.25 % and 89.65 % respectively for sundried *Blighia sapida* aril oil which was comparable to the 93.46 % reported in the present study. However, reports by [49] and [50] revealed a higher unsaturated fatty acid composition of 58.5 % and 65.17 % for oven dried and roasted aril oils of *Blighia sapida*. Several factors could be responsible for the disparities detected in the fatty acid profile of the oil across different studies. These include genetic variation in plant species, geographical origin, stage of fruit maturity, and processing methods such as sun and oven drying, roasting and also different storage methods [50].

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Table 3: Fatty Acids Composition of *Dacryodes edulis* pulp Oil Extract

Compound	Molecular weight	Molar mass (g/mol)	Retention time	Area (%)	Classification	Total (%)
Eicosanoic acid	$C_{20}H_{40}O_2$	312	13.919	0.81	SFA	SFA= 59.38
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	16.275	1.15	SFA	UFA= 39.3
n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	19.138	45.60	SFA	FAME=1.31
9,12-Octadecenoic acid (z,z)-, methyl ester	$C_{19}H_{34}O_2$	294	20.985	0.56	FAME	PT= 99.99
Pentadecanoic acid, methyl ester	$C_{16}H_{32}O_2$	256	21.224	0.75	FAME	
9,12-Octadecenoic acid (z,z)	$C_{18}H_{32}O_2$	280	21.304	4.04	UFA	
Oleic acid	$C_{18}H_{34}O_2$	282	21.386	35.26	UFA	
Docosanoic acid	$C_{22}H_{44}O_2$	340	21.652	11.82	SFA	

SFA= Saturated fatty acid, UFA= Unsaturated fatty acid, FAME= Fatty acid methyl ester, PT= Percentage total

Table 3 reveals the result of the fatty acid composition of the pulp oil extract of *Dacryodes edulis*. Eight compounds were present with their percentage concentrations namely; Eicosanoic acid (0.81 %), Tetradecanoic acid (1.15 %), n-hexadecanoic acid (45.60 %), 9,12- Octadecenoic acid (z,z), methyl ester (0.56 %), Pentadecanoic acid, methyl ester (0.75 %), 9,12- Octadecenoic acid (z,z) (4.04 %), Oleic acid (35.26 %) and Docosanoic acid (11.82 %). The total saturated fatty acid content was 59.38%, n-hexadecanoic acid (45.60 %) was the most abundant which is consistent with recent studies on *Dacryodes edulis* pulp oil [51] [52]. Docosanoic acid, while less common in other edible oils, was found at a high concentration, an indication of the oil's stability and industrial applicability. This study reported a higher total saturated fatty acid content than the 12.37 % and 33.6 % reported by [52] and [53] for African pear pulp oil. [54] reported a closer value of 58.76 %. The high saturated fatty acid content will contribute to oxidative resistance, giving the oil a longer shelf life and improved thermal stability. The total unsaturated fatty acids content was 39.30 % with oleic a monounsaturated and 9,12-Octadecenoic acid (z,z) a poly unsaturated acid been the only two detected. They have a beneficial effect on lipid metabolism, essential for human nutrition and play a role in skin barrier function and immune modulation [55]. [56] and [9] reported higher values of 63.53 % and 60.81 % while [57] reported a similar value of 39.70 % for African pear pulp oil.

FAMEs made up 1.31 % of the oil, including: 9,12-Octadecenoic acid (z,z), methyl ester: 0.56 % and Pentadecanoic acid, methyl ester: 0.75 %. The presence of these methyl esters suggests minor components with biodiesel potential. These compounds could also influence the volatility and viscosity of the oil which makes it relevant for industrial processing [58].

Table 4: Fatty Acids Composition of *Cyperus esculentus* Tuber Oil Extract

Compound	Molecular weight	Molar mass (g/mol)	Retention time	Area (%)	Classification	Total (%)
Heptadecanoic acid	$C_{17}H_{34}O_2$	270	17.608	0.49	SFA	SFA= 34.08
Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	284	18.582	19.21	FAME	UFA= 40.43
Docosenoic acid	$C_{22}H_{42}O_2$	338	18.824	6.69	UFA	FAME=25.48
n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	19.128	28.24	SFA	PT= 99.99
9-Octadecenoicacid, methyl ester	$C_{19}H_{36}O_2$	296	20.925	4.67	FAME	
Oleic acid	$C_{18}H_{34}O_2$	282	21.398	33.74	UFA	
Octadecanoic acid	$C_{18}H_{36}O_2$	284	21.665	4.81	SFA	
Eicosanoic acid	$C_{20}H_{40}O_2$	312	23.062	0.54	SFA	
Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326	23.377	0.23	FAME	
Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354	26.801	1.37	FAME	

Key: SFA= Saturated fatty acid, UFA= Unsaturated fatty acid, FAME= Fatty acid methyl ester, PT= Percentage total

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Table 4 reveals the result of the fatty acid composition of the tuber oil extract of *Cyperus esculentus*. Ten compounds were present with their percentage concentrations namely; Heptadecanoic acid (0.49 %), Heptadecanoic acid, methyl ester (19.21 %), Docosenoic acid (6.69 %), n-hexadecanoic acid (28.24 %), 9- Octadecenoic acid, methyl ester (4.67 %), Oleic acid (33.74 %), Octadecanoic acid (4.81 %), Eicosanoic acid (0.54 %), Eicosanoic acid, methyl ester (0.23 %) and Docosanoic acid, methyl ester (1.37 %). The total unsaturated fatty acid content was 40.43 %, with oleic acid the most abundant unsaturated fatty acid. Its high presence is particularly significant as oleic acid is known for its health benefits, such as improving heart health by lowering cholesterol levels. Oleic acid also exhibits anti-inflammatory and antioxidant properties, which may protect against chronic diseases [59]. The 33.74 % reported in this study for oleic acid was lower than the 66.83 % and 67.08 % for raw and roasted tiger nut oil those reported by [60]. [61] also reported 73.47 % and 73.00 % for roasted and boiled tiger nut oil. It was however higher than the 18.57 % reported by [62]. When compared with [60] and [61], some differences were observed between the values of the present study and those reported by them. However, it was observed that the dominant unsaturated fatty acid was the same. The difference may be due to the variety, genetic structure, temperature demand during the growing period and harvest time [62].

The total saturated fatty acid content was 34.08 % with n-hexadecanoic acid (28.24 %) been the most abundant. The value is higher than the 15.32 % reported by [63] and 19.02 % by [64] for solvent extracted tiger nut oils. [59] and [65] reported 21.27 % and 24.46 % respectively. Certain factors including methods of extractions, environmental and agronomic factors and storage and processing conditions could be responsible for the high saturated fatty acid composition of this study compared with literature. [66] reported that drought-stressed or heat exposed plants often have higher saturated fatty acid content, which helps to maintain membrane stability. Extraction techniques especially involving heat, non-polar solvents or grinding/roasting can selectively increase recovery of saturated fatty acids [21].

Fatty acid methyl esters collectively make up 25.48 % of the total fatty acid profile. Key FAMEs identified include: Heptadecanoic acid, methyl ester (19.21 %), 9-Octadecenoic acid, methyl ester (4.67 %), Docosanoic acid, methyl ester (1.37 %) and Eicosanoic acid, methyl ester (0.23 %). The substantial FAME content is indicative of the oil's potential for biofuel production, as methyl esters are primary components of biodiesel and could serve as a renewable feedstock for sustainable energy applications [67].

4.0 CONCLUSION

The oils from *Blighia sapida* aril, *Dacryodes edulis* pulp, and *Cyperus esculentus* tuber exhibited physicochemical parameters within edible oil standards. The variations reflected differences in stability, degree of unsaturation and industrial suitability. Fatty acid composition revealed *Blighia sapida* oil as predominantly saturated, indicating oxidative stability. *Dacryodes edulis* oil contains a balanced proportion of unsaturated fatty and saturated acids and is particularly rich in oleic acid while *Cyperus esculentus* oil is highly unsaturated with significant fatty acid methyl esters. This highlights the nutritional and biofuel potential of the oils. The results emphasize the value of these selected plant oils as alternative sources for food, health, and industrial applications.

Conflict of Interest

The authors declare no conflicts of interest related to this work.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Authors' Contributions

Tsado, D. B. contributed to the literature search, data organization, and manuscript drafting. All authors revised the manuscript for intellectual content, developed the conceptual framework, validated data, supervised the study, and coordinated the writing process. All authors approved the final version.

Authors' Declaration

The authors certify that this research is original, has not been published previously, and is not under consideration by any other journal. We assume full responsibility for the integrity of the data and the accuracy of the reported findings and will accept all liability for any claims about the content.

Ethical Declarations – Human/Animal Studies

Not applicable.

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