Lafia Journal of Scientific & Industrial Research (LJSIR), Vol. 4(1), 2026
p-ISSN: 3026 – 9288 e-ISSN: 3027 – 1800 pages: 55 – 62
https://lafiascijournals.org.ng/index.php/ljsir/index ⇒ Published by the Faculty of Science,
Federal University of Lafia, Nasarawa State, Nigeria

Fatty Acid Profiles, Physicochemical Characteristics and Phytosterols of Three Underexploited Fruit Kernels and Pulps from North-East, Nigeria

Matthew Olaleke Aremu, Emmanuel Ezekiel*, Abdullahi Usman, Idzi Amos Ambo, Jude Chinedu Onwuka, Hamza Ibrahim Muhammad
Department of Chemistry, Federal University of Lafia, PMB 146, Nasarawa State, Nigeria

Abstract

This paper examines the fatty-acid profiles, physicochemical properties, functional lipid indices and phytosterol composition of oils in the kernels and pulps of three underexploited fruits namely; *Hyphaene thebaica* (Doum palm), *Diospyros mespiliformis* (Jackal-berry), and *Detarium senegalense* (Sweet detar) as found in North-East Nigeria. The standard analytical techniques were used for different analyses. Physicochemical measurements indicated obvious species- and tissue-specific differences, Doum palm kernel having the highest acid and viscosity, and peroxide levels were low in all samples, meaning there were minimal oxidative damages. The oils were anaesthetized by colour parameters (CIELAB) as being light, with mild rates of the green-yellow liquids and sample-specific brightness. The fatty-acid analysis showed the highest level of myristic acid (8.27%) in jackal-berry kernel and the highest content of oleic acid (30.20%) in sweet detar pulp. Linoleic and α-linolenic acids were present in physiologically relevant amounts, the highest values recorded in jackal–berry pulp (28.50%) and jackal–berry kernel (16.83%), respectively. The quality of lipid indices showed positive nutritional profiles with MUFA/SFA and PUFA/SFA ratios being over 1.00 with low atherogenicity and thrombogenicity indices and ω-6/ω-3 ratios in the anti-inflammatory range values. Phytostersol analysis revealed that sweet detar pulp has the highest sitosterol (0.823 mg/100g) and ergosterol (0.653 mg/100g); doum kernels showed high level of campesterol (0.747 mg/100g) and avenasterol (0.83 mg/100g). Generally, these results highlighted the nutritional value, biochemical composition, and functional prospects of these underexploited fruit oils, thereby recommending them as foods, nutraceutical and cosmetic ingredients.

Keywords: Fatty acids, physicochemical properties, phytosterols, underexploited fruits

Article History

Submitted
November 03, 2025

Revised
December 18, 2025

First Published Online
December 20, 2025

Correspondences
E. Ezekiel ✉
ezekielemmanueltsp@gmail.com

doi.org/10.62050/ljsir2026.v4n1.700

Introduction

In Nigeria, there are many wild and semidomesticated fruits which have not been optimally exploited despite their richness in bioactive and health-promoting compounds [1]. The underexploited indigenous fruit trees offer an important but little explored opportunity for the improvement both of nutrition and livelihoods in rural and for agro-industrial diversification across sub-Saharan Africa. In North-East Nigeria, for example, some species including *Diospyros mespiliformis* (Jackal–berry), *Hyphaene thebaica* (Doum palm) and *Detarium senegalense* (Sweet detar) are culturally important but underexploited although the importance of the latter and the high nutritional and functional potential of these species is gaining recognition [2, 3].

These fruits are adapted to the region's arid and semi-arid ecology, and so they are sustainable sources of food and industrial raw materials. *Detarium senegalense* has a high value in terms of its nutrient-rich pulp and the importance of this species is in accord with its medicinal value yet most of the consumption is still informal and receives little focus in terms of scientific research. *Hyphaene thebaica* produces brightly coloured and fibre-rich fruits that are very widely used in native diets of all parts of Africa, and *Diospyros mespiliformis* produces vitamin-rich fruits and medicinal leaves, which are used in the use of fever and infections [4].

Fatty-acid composition and physicochemical features of their kernels and pulps are important since they are substrates of the nutritional quality, oxidative stability, the functionality and of their industrial suitability. Oils containing unsaturated fatty acids in high amounts, especially oleic, linoleic, and α-linolenic acids are associated with cardio-protection and an anti-inflammatory effect [1, 5]. Likewise, physicochemical indices are capable of providing information about oil purity, shelf stability, and possible applications for processing [3, 6]. Characterization of these properties in underexploited fruits therefore, provides essential data counts in promoting their food, nutraceutical, and industrial use as well as minimizing post-harvest losses which is the main objective of this study.

Materials and Methods

Samples collection

The kernel and pulp samples of *Hyphaene thebaica* (Doum palm), *Diospyros mespiliformis* (Jackal–berry), and *Detarium senegalense* (Sweet detar) were collected from farming villages in Lankaviri (Taraba), Mayo-Belwa (Adamawa), Toro (Bauchi), and Biu (Borno) States of Northeastern Nigeria. The samples were authenticated at the Department of Plant Science and Biotechnology, Federal University of Lafia, Nigeria.

Samples preparation and treatment

The *Hyphaene thebaica* (Doum palm), *Diospyros mespiliformis* (Jackal–berry) and *Detarium senegalense* (Sweet detar) pulp and kernel fruits were properly rinsed thoroughly with distilled water to get rid of any impurities. Each fruit was sun-dried, separated into pulp and kernel, and ground into a fine powder using a pestle and mortar. The powder was sieved, stored in properly labeled airtight plastic containers, and then taken to the laboratory for analysis.

Extraction of oils

The reagents and apparatus used for the extraction were as follows: Condenser Soxhlet extraction unit, oven, desiccator, weighing balance, thimble, heating mantle, the glass wool and no 4 filter paper, 250 ml capacity boiling flask and petroleum ether (40 – 60^{o}C). 250 ml capacity extracting flask was dried in the oven at 105^{o}C and then transferred to the desiccator to reach laboratory temperature and the weight of the flask was measured. Exactly 2.5 g of each of the oven-dried samples of kernel and pulp was weighed into the labelled porous thimble. To a dry 250 ml conical flask, 200 ml of petroleum ether was added. The covered porous thimble with the sample was placed in the condenser of the Soxhlet extractor arrangement assembled. The extraction time of the sample was 5 h. The porous thimble was carefully removed and the petroleum ether located in the top container (tube) was collected for reuse. Extraction flask was removed from heating mantle arrangement when it was almost free from petroleum ether. The extraction flask containing the oil was cooled in the desiccator, and the weight of the cooled flask containing the dried oil was measured [7]. All chemicals are of Analar grade (British Drug Houses, London).

Determination of physicochemical parameters

The acid value, peroxide value, iodine value, saponification value, specific gravity, kinematic viscosity, and refractive index of the extracted oils of kernel and pulp of *Hyphaene thebaica* (Doum palm), *Diospyros mespiliformis* (Jackal-berry), and *Detarium senegalense* (Sweet detar) were determined according to AOAC [7]. Three determinations were carried out on each sample.

Analysis of fatty acid profiles

Total lipid was extracted from 1 g sample using the chloroform: methanol (2:1, v/v; containing BHT 0.1 mg/100g) method [8]. For the determination of fatty acid composition, in order to have more representative samples, lipid extracts were pooled together for preparation of fatty acid methyl esters (FAME) and two such pooled samples were analyzed. The lipids were transmethylated using 2 M methanolic sodium hydroxide, followed by 2M methanolic hydrochloric acid to obtain FAME. FAMEs were analyzed by gas chromatography (Shimadzu GC-2014, Japan) for identifying the individual fatty acids. FAME dissolved in hexane was analyzed using Omega wax TM 320 fused silica capillary column (30 m × 0.32 mm × 0.25 µm). The conditions used for GC analysis injection are temperature of 250°C, a detector (FID) temperature of 260°C, and a column temperature of 200°C for 60 min. The carrier gas was hydrogen or helium for use in gas chromatography. The peaks were identified by comparing with authentic standards. The fatty acid analyses were conducted in triplicate.

Functional quality of the oil samples

The function of the lipid fractions was assessed based on the fatty acid proportions in their lipid profiles, analyzed using four compositional indices. The ratio of omega-6 to omega-3 equation (1), hypocholesterolemic/hypercholesterolemic (H/H) ratio equation (2) [9], atherogenicity index (AI), equation (3), and thrombogenicity index (TI) equation (4) [10] as reported by Aremu *et al.* [11].

$$\frac{\omega-6}{\omega-3} = \frac{\Sigma(\text{n}-6 \text{ fatty acids})}{\Sigma(\text{n}-3 \text{ fatty acids})} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{H}{H} = \frac{(\text{C18:1 cis}-9 + \text{C18:2 n}-6 + \text{C20:4 n}-6 + \text{C18:3 n}-3 + \text{C20:5 n}-3 + \text{C22:5 n}-3 + \text{C22:6n3})}{(\text{C14:0} + \text{C16:0})} \quad \ldots\ldots (2)$$

$$\text{AI} = \frac{(\text{C12:0} + (4 \times \text{C14:0}) + \text{C16:0})}{(\Sigma\text{MUFA} + \Sigma\text{PUFA (n}-6 \text{ and n}-3))} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{TI} = \frac{(\text{C14:0} + \text{C16:0} + \text{C18:0})}{((0.5 \times \Sigma\text{MUFA}) + (0.5 \times \Sigma\text{PUFA (n}-6)) + (3 \times \Sigma\text{PUFA (n}-3)) + (\text{n}-3/\text{n}-6))} \quad \ldots\ldots (4)$$

Phytosterol analysis

Briefly, 1 g portion of each sample was weighed into a 50 mL-size Falcon tube. The tube was added with 15 ml of acetonitrile and 10 ml of distilled water and vigorously mixed for 1 min using a vortex mixer. The tubes were then added 6 g of $MgSO_4$ and 1.5 g of sodium acetate and immediately mixed for 1 min. The tube was centrifuged at 3000 rpm for 5 min using a tabletop centrifuge. The organic phase was transferred carefully into a 50 mL-size falcon tube containing 300 mg of PSA and 900 mg of $MgSO_4$ and mixed vigorously for 1 min. The tube was centrifuged again as described above. An aliquot of the extract was subjected to HPLC for analysis.

The calibration curves of phytosterols were prepared with working solutions in a range of 0.001 to 100 mg/L which had been diluted from the stock solutions (10 mg/L). An aliquot of the working solutions in triplicate was injected onto HPLC, and their linearity was investigated on the basis of peak area. The accuracy of detection was determined by injecting three preparations of phytosterols added to the control samples at a level of 0.1 mg/L, calculating the relative standard deviation [12].

Statistical analysis

Data for this study were analyzed using ANOVA to determine significant differences between samples using SPSS version 25, followed by Tukey's HSD post-hoc test to separate means at $p < 0.05$.All measurements were reported in triplets and expressed as mean ± SD (Standard Deviation).

Results and Discussion

Physicochemical characteristics of oil extracted from the pulps and kernels of doum palm, jackal–berry and sweet detar

The physicochemical properties of oils from the three fruit samples indicated a defined sample-dependent variability in accordance with previous results on oils from African wild fruits [13, 14]. Acid value varied moderately between samples, with the highest values being recorded in Doum palm kernel, indicating it had a higher content of free fatty acids and perhaps advanced hydrolysis of the lipids. In contrast, Jackal-berry pulp and Doum palm pulp had low acid values which indicated more fresher and stable oils. This pattern is in agreement with reports that kernel oils are often in a higher free fatty acid (FFA) state because of the enzymatic activity going on during seed maturation [15].

The peroxide values were generally low among all the samples, this would show that there was little primary oxidation of the oils and that they would have not been rancid at the time of extraction. Sweet detar pulp and doum palm pulp registered slightly higher values but all were within acceptable limits of quality for edible oils (Table 1). These results are consistent with earlier observations that fruit oils with unsaturated fatty acids can be more prone to oxidation while containing the stability of freshly extracted oils [16].

Iodine values showed considerable variation with differences in the degree of unsaturation. Doum palm kernel (165.38 ± 0.58) and doum palm pulp (173.02 ± 0.43) had higher iodine values, hence more unsaturated fatty acids in them compared with Jackal-berry pulp (Table 1). This is in line with recorded diversity in unsaturation amongst indigenous fruit oils [17]. Similarly, the saponification values varied considerably and the sweet detar pulp was found to have the highest saponification values, indicating a higher proportion of short- and medium-chain fatty acids, which is desirable in soaps and cosmetics.

Specific gravity, density, refractive index and viscosity were within expected values for edible and cosmetic oils. It is interesting to note also that viscosity was highest with doum palm kernel and sweet detar pulp, which implies that they contained thicker and more polymer-rich oils. These structural differences impact on potential industrial applications, as emollients, lubricants or specialty fats [18].

The colour profile was with a universal colour system (CIELAB). It is an internationally recognized colour measurement system, which was invented by the International Commission on Illumination (CIE). It is used widely for the quantitative determination of the colour of food products, oils, pigments, surfaces and biological materials. It has three elements: **L*** = lightness (0 = black, 100 = white). Higher L' means a brighter or lighter-looking oil.

- **a*** = red–green balance (positive = more red, negative = more green).
- **b*** = yellow–blue balance (positive = more yellow, negative = more blue).

Most samples have slightly negative a^* values (-0.96 to -0.43), which means that they leaned gently towards the green, rather than the red direction. The b* values ranged from -0.99 to 0.28. Slightly negative b* was a bit of a blue-green tint while slightly positive b* was a little bit yellowish tint. Result from Table 1 showed that the oil from jackal berry pulp was light having (slightly) greenish yellow shade, oil from jackal-berry kernel shade was faint yellowish green, oil from doum palm kernel was moderately bright oil with mild greenish yellow shade, oil produced from the pulp of doum palm appeared slightly brighter oil with mild green undertone, oil produced from sweet detar pulp and kernel was greenish yellow.

Table 1: Physicochemical characteristics of oil extracted from pulp and kernel of doum palm, jackal berry and sweet detar

Parameter	Doum palm		Jackal-berry		Sweet detar	
	Kernel	Pulp	Kernel	Pulp	Kernel	Pulp
Acid value (mg KOH/kg)	670.78 ± 3.35	316.41 ± 2.23	354.38 ± 2.50	291.10 ± 2.05	253.13 ± 1.77	367.03 ± 2.57
Peroxide value (meq/kg)	0.82 ± 0.01	2.40 ± 0.01	2.80 ± 0.02	2.19 ± 0.01	0.41 ± 0.01	1.59 ± 0.01
Iodine value (mg I_2/100g)	165.38 ± 0.58	173.02 ± 0.43	165.28 ± 0.58	119.58 ± 0.42	162.84 ± 0.57	157.75 ± 0.56
Saponification value (mg KOH/kg)	201.76 ± 0.29	196.15 ± 0.28	134.51 ± 0.19	145.71 ± 0.21	218.57 ± 0.31	218.57 ± 0.31
Specific gravity	0.89 ± 0.01	0.91 ± 0.01	0.90 ± 0.01	0.91 ± 0.01	0.89 ± 0.01	0.88 ± 0.01
Density (g/mL)	0.90 ± 0.01	0.91 ± 0.01	0.89± 0.01	0.91 ± 0.01	0.90 ± 0.01	0.89± 0.01
Refractive index	1.33 ± 0.01	1.34 ± 0.01	1.33 ± 0.01	1.34 ± 0.01	1.33 ± 0.01	1.33 ± 0.01
Viscosity (mPa·s)	3346.80 ± 11.70	529.60 ± 0.99	604.95 ± 1.63	3298.85 ± 11.22	681.35 ± 1.46	1874.35 ± 6.31
Unsaponifiable matter (%)	0.54 ± 0.01	0.68 ± 0.01	0.51 ± 0.01	0.43 ± 0.01	0.43 ± 0.01	0.54 ± 0.01
Colour (L*)	4.27 ± 0.08	2.12 ± 0.01	2.35 ± 0.01	2.43 ± 0.03	2.10 ± 0.01	2.12 ± 0.01
Colour (a*)	–0.74 ± 0.01	–0.44 ± 0.01	–0.76 ± 0.01	–0.95 ± 0.01	0.54 ± 0.01	–0.44 ± 0.01
Colour (b*)	0.16± 0.02	–0.98 ± 0.01	0.275 ± 0.01	0.13 ± 0.01	0.26± 0.01	–0.97 ± 0.01

the values are reported as mean ± SD, n = 3

Table 2: Fatty acid composition of the extracted oil from three underexploited fruits

Fatty acid (%)	Doum palm		Jackal-berry		Sweet detar	
	Kernel	Pul p	Kernel	Pulp	Kernel	Pulp
Myristic acid	3.23 ± 0.15^{a}	4.73 ± 0.21^{b}	8.27 ± 0.12^{c}	0.54 ± 0.02^{d}	6.37 ± 0.12^{e}	4.43 ± 0.12^{b}
Palmitic acid	2.13 ± 0.02^{a}	26.23 ± 0.55^{b}	13.30 ± 0.10^{c}	23.63 ± 0.73^{b}	19.53 ± 0.15^{d}	23.33 ± 0.15^{b}
Stearic acid	3.40 ± 0.10^{a}	6.50 ± 0.20^{b}	5.53 ± 0.15^{b}	5.43 ± 0.15^{b}	9.73 ± 0.21^{c}	6.47 ± 0.15^{b}
Myristoleic acid	0.90 ± 0.20^{a}	1.17 ± 0.12^{a}	2.23 ± 0.15^{b}	2.27 ± 0.15^{b}	5.43 ± 0.15^{c}	3.67 ± 1.53^{d}
Palmitoleic acid	9.73 ± 0.21^{a}	14.77 ± 0.15^{b}	9.37 ± 0.15^{a}	8.73 ± 0.15^{a}	9.77 ± 0.15^{a}	14.47 ± 0.29^{b}
Cis-10-Heptadecenoic acid	0.73 ± 0.12^{a}	3.23 ± 0.15^{b}	0.93 ± 0.15^{a}	0.47 ± 0.10^{a}	0.63 ± 0.15^{a}	1.03 ± 0.12^{c}
Oleic acid	28.70 ± 0.17^{a}	26.63 ± 0.25^{b}	18.73 ± 0.15^{c}	21.17 ± 0.12^{d}	21.57 ± 0.21^{d}	30.20 ± 0.17^{e}
Erucic acid	2.33 ± 0.15^{a}	1.37 ± 0.12^{b}	1.77 ± 0.15^{b}	2.23 ± 0.15^{a}	0.97 ± 0.12^{c}	1.83 ± 0.12^{b}
Linoleic acid	24.87 ± 0.50^{a}	20.70 ± 0.17^{b}	21.30 ± 0.20^{b}	28.50 ± 0.20^{c}	20.37 ± 0.23^{b}	21.30 ± 0.20^{b}
Linolenic acid	9.23 ± 0.15^{a}	10.30 ± 0.20^{b}	16.83 ± 0.10^{c}	9.43 ± 0.12^{a}	16.40 ± 0.10^{c}	8.53 ± 0.15^{a}
Docosahexaenoic acid (DHA)	1.57 ± 0.06^{a}	1.23 ± 0.12^{b}	1.47 ± 0.06^{a}	0.23 ± 0.06^{c}	2.23 ± 0.15^{d}	0.83 ± 0.06^{e}
Eicosapentaenoic acid (EPA)	4.13 ± 0.06^{a}	2.23 ± 0.06^{b}	1.33 ± 0.06^{c}	4.40 ± 0.10^{d}	1.57 ± 0.12^{e}	4.40 ± 0.10^{d}

Values are reported as mean ± SD, n = 3. a,b,c,d,e,f = significant differences ($p < 0.05$) within each row

Fatty acid composition

The fatty acid composition of the oils (Table 2) of the doum palm, jackal-berry, and sweet detar exhibited definite quantitative differences between kernel and pulp from the species and tissue-specific lipid metabolism reported in earlier studies on fruit oils of Africa [19, 20]. Significant differences ($p < 0.05$) among samples were found for saturated fatty acids as determined by analysis of variance (ANOVA) and different Tukey HSD superscripts. Myristic acid for example was at its maximum value in jackal-berry kernel (8.27 ± 0.12) and at its lowest amount in the pulp (0.54 ±0.02) which showed a strong tissuedependent partitioning. Palmitic acid also followed a similar trend with the level of doum palm pulp being significantly higher (26.23± 0.55) than its kernel consistent with previous reports that pulps were often rich in accumulated SFAs [17].

There were also statistically distinct trends in unsaturated fatty acids. Sweet detar pulp showed the maximum oleic acid concentration (30.40± 0.30%), which was in harmony with the reports that *Detarium genus* and other wild fruits commonly have MUFA-rich lipid profiles [14]. Coefficients of variation were used to further show the biochemical heterogeneity among the fruits: the variation in content of myristoleic and heptadecenoic acids were high (more than 60%), whereas linoleic acid showed a relatively stable regulation [15].

Comparatively, the profiles of fatty acids were in the range of several African wild fruits. High oleic acid in sweet detar was similar to baobab and shea oils [21], and high palmitic acid in doum palm pulp was similar to palm oil (*Elaeis guineensis*) [17]. Jackal-berry kernel's unusually high myristic acid resembled patterns of coconut and cupuacu butter [22]. The high linoleic acid content of jackal-berry pulp was comparable to the wild melon and roselle seed oils, and therefore has potential nutraceutical values [17, 23].

Quality parameters

The lipid quality indices of a total of six fruit oils revealed a favourable profile of the fatty acids with impulse differences between samples. SFA content was

moderate which was consistent with indigenous fruit oils that harmonized stability with nutrition [16, 24], and was similar to African black pear and tiger-nut oils in which moderate SFA enhanced the thermal performance without increasing the cardiovascular risk [11]. MUFA were similar to avocado and *Dacryodes edulis* oils [25, 26] with known beneficial effects in serum-lipid regulation and oil oxidative stability [27]. PUFA contributions marked the presence of linoleic and alpha-linolenic acids related to anti-inflammatory and neuroprotective functions [28 – 30].

Table 3: Quality parameters of extracted oil from the kernel and pulp of three underexploited fruits

Parameter	Doum Palm		Jackal berry		Sweet Detar	
	Kernel	Pulp	Kernel	Pulp	Kernel	Pulp
Total SFA	2.80 ± 0.04^{a}	3.75 ± 0.10^{c}	2.71 ± 0.02^{a}	3.45 ± 0.08^{b}	3.56 ± 0.04^{b}	3.42 ± 0.02^{b}
Total MUFA	4.24 ± 0.04^{d}	4.72 ± 0.02^{e}	3.30 ± 0.05^{a}	3.49 ± 0.04^{b}	3.84 ± 0.03^{c}	4.79 ± 0.04^{e}
Total PUFA	3.98 ± 0.05^{b}	3.45 ± 0.03^{a}	4.09 ± 0.01^{c}	4.26 ± 0.03^{d}	4.06 ± 0.05^{b}	3.51 ± 0.01^{a}
DUFA	1.49 ± 0.02^{b}	1.38 ± 0.03^{a}	1.96 ± 0.01^{c}	1.41 ± 0.02^{a}	2.02 ± 0.04^{c}	1.38 ± 0.02^{a}
Total UFA	8.22 ± 0.04^{d}	8.16 ± 0.05^{d}	7.40 ± 0.06^{a}	7.74 ± 0.01^{b}	7.89 ± 0.04^{c}	8.30 ± 0.06^{e}
MUFA/SFA	1.52 ± 0.03^{d}	1.26 ± 0.03^{b}	1.22 ± 0.03^{b}	1.01 ± 0.023^{a}	1.08 ± 0.02^{a}	1.40 ± 0.02^{c}
PUFA/SFA	1.42 ± 0.03^{c}	0.92 ± 0.02^{a}	1.51 ± 0.01^{f}	1.24 ± 0.03^{d}	1.14 ± 0.01^{c}	1.02 ± 0.01^{b}
Total EFA	3.98 ± 0.05^{b}	3.45± 0.03^{a}	4.09 ± 0.01^{c}	4.256± 0.03^{d}	4.06 ± 0.05^{b}	3.51 ± 0.01^{a}
O/L	1.15 ± 0.03^{d}	1.29 ± 0.02^{e}	0.88 ± 0.01^{b}	0.74 ± 0.01^{a}	1.06 ± 0.01^{c}	1.42 ± 0.02^{f}

Values are mean ± SD, n = 3. a, b, c, d, e, f = significant differences ($p < 0.05$) within each row

Table 4: Functional quality of the extracted oil from three underexploited fruits

Sample	Doum palm		Jackal–berry		Sweet detar	
	Kernel	Pulp	Kernel	Pulp	Kernel	Pulp
ω-6/ω-3	1.665 ± 0.044^{c}	1.504 ± 0.039^{b}	1.085 ± 0.016^{a}	2.026 ± 0.017^{d}	1.008 ± 0.015^{a}	1.548 ± 0.040^{b}
H/H	3.346 ± 0.051^{c}	2.637 ± 0.055^{a}	3.430 ± 0.023^{c}	2.668 ± 0.069^{a}	3.048 ± 0.026^{b}	2.988 ± 0.026^{b}
AI	0.417 ± 0.010^{a}	0.553 ± 0.015^{c}	0.627 ± 0.001^{e}	0.584 ± 0.013^{d}	0.570 ± 0.007^{c}	0.495 ± 0.004^{b}
TI	0.331 ± 0.003^{b}	0.458 ± 0.011^{f}	0.284 ± 0.002^{a}	0.437 ± 0.009^{e}	0.357 ± 0.002^{c}	0.416 ± 0.007^{d}

Values are mean ± SD, n = 3. Superscript letters (a, b, c, d, e, f) denote significant differences ($p < 0.05$) within each row

Functional quality of extracted oil

The indices of functional quality in Table 4 gave a clear picture about the cardiometabolic potential of six fruit oils. The ratios of the ω-6/ω-3 (1.0–2.0) were within the physiologically good range, and much lower than the pro-inflammatory values (>10:1) found in average diets [33] Samples representing the lowest superscripts were the most anti-inflammatory oils, confirming that there were meaningful inter-sample differences ($p < 0.05$). The H/H ratio was high in all samples (2.5–3.4), similar to nutrient-dense African oils (e.g. *Mangifera indica* and *Anarcadium occidentale*) [34]. Oils that fall into higher H/H superscript groups thus have better cholesterol-lowering potential in line with evidence of a beneficial effect of oleic, linoleic and alpha linolenic acids on LDL metabolism and cardiovascular risk [27, 35]. Atherogenicity (AI) and thrombogenicity (TI) indexes showed a uniform low rank, indicating a favourable fatty acid balance that inhibits the formation of atheroma and thrombi [36] similar to pumpkin, chia and cold pressed berry oils [37, 38]. Statistically unique superscripts are used to point out oils that have the highest cardioprotective potential.

Overall, fatty acid characteristics corresponded to patterns reported for baobab, peanut, olive, shea and marula oils [39-41] where high oleic and linoleic acids were good for cardiovascular protection and inferior saturated fats are better than tropical oil derived from palms and coconuts [42].

When placed within the context of other natural and commercial wild and common fruit oils, the fatty acid properties displayed by these samples suggest trends observed in reports for baobab, peanut, olive, shea and marula oil, which all have favourable unsaturated to saturated fatty acid ratios [39-41]. The high oleic and linoleic acid profiles noted here was similar to the lipid profiles of the high-value fats with proven cardioprotective properties, whereas the relatively low saturated fractions compared favorably with several common tropical oils, including palm and coconut oils [42].

Phytosterol composition

Phytosterol levels of the phytosterol profile of kernel and pulp of doum palm, jackal-berry and sweet detar exhibited inter-species and inter-tissue variation with sitosterol, stigmasterol, campesterol, ergosterol and avenasterol observed to occur in varying ratios. As shown in Table 5, statistical superscript letters (a-f) represented the significant differences ($p < 0.05$) within each of sterol parameters, in accordance with the usual ANOVA and post-hoc comparison method, frequently employed in the compositional researchers [19, 43].

Table 5: Phytosterol composition (mg/100g) of doum palm, jackal berry and sweet detar

Phytosterol Parameter	Doum Palm		Jackal–berry		Sweet Detar	
	Kernel	Pulp	Kernel	Pulp	Kernel	Pulp
Sitosterol	0.25 ± 0.02[a]	0.73 ± 0.02[e]	0.54 ± 0.03[c]	0.34 ± 0.02[b]	0.45 ± 0.03[d]	0.82 ± 0.02[f]
Stigmasterol	0.33 ± 0.02[a]	0.66 ± 0.03[e]	0.45 ± 0.02[b]	0.44 ± 0.02[b]	0.53 ± 0.02[c]	0.65 ± 0.03[d]
Campesterol	0.75 ± 0.02[e]	0.31 ± 0.02[b]	0.46 ± 0.03[c]	0.94 ± 0.01[f]	0.22 ± 0.02[a]	0.44 ± 0.03[d]
Ergosterol	0.34 ± 0.01[a]	0.54 ± 0.01[d]	0.43 ± 0.01[b]	0.44 ± 0.01[c]	0.56 ± 0.01[e]	0.65 ± 0.01[f]
Avenasterol	0.83 ± 0.01[e]	0.75 ± 0.01[d]	0.54 ± 0.01[b]	0.76 ± 0.02[d]	0.62 ± 0.06[c]	0.65 ± 0.01[e]

Values are reported as mean ± SD, n = 3. a,b,c,d,e,f = significant differences ($p < 0.05$) within each row

In the three fruits, sweet detar pulp had the highest level of sitosterol (0.823 ± 0.015 mg/100g) and ergosterol (0.653 ± 0.006 mg/100g), with doum kernel having the highest amount of avenasterol (0.83 ± 0.01 mg/100g) and campesterol (0.747 ± 0.015 mg/100g). Jackal-berry exhibited moderately and wellbalanced kernel and pulp sterol profiles. The patterns were consistent with the previous information regarding phytosterol distribution, which heavily depended on the species and was genetically determined [44, 45].

The observed pattern of sterol dominance, namely, sitosterol, campesterol, and stigmasterol in most samples, correlates well with the sterol structure of much of African wild fruit [45, 46]. The absolute concentrations were lower compared to conventional oilseeds but the ratio distribution promised useful functional capabilities especially in cholesterol-modulating uses, in that sitosterol and campesterol successfully prevented intestinal cholesterol incorporation [45].

Conclusion

This paper has established that the doum palm, jackal-berry and sweet detar kernel and pulp oils have nutritionally valuable and compositionally diverse lipid profiles. Their moderate MUFA and PUFA dominance, favourable MUFA/SFA and PUFA/SFA ratios, low AI and TI values, among others, are evidence of a potential of high cardioprotective and hypocholesterolemic. The importance of kernel and the pulp difference ($p < 0.05$) is clear biochemical difference, whereas colour, viscosity, saponification and iodine value indicated the suitability of the product as a nutritional and industrial product. Phytosterol profiles which were high especially in sweet detar and doum palm also support a cholesterol lowering activity. All in all, these underexplored fruits have potential substitutes to edible oils, nutraceuticals and agro-industrial applications with potential outcomes to improve nutrition and livelihoods among rural communities of North-East Nigeria.

Conflict of interest: The authors have declared that there is no conflict of interest reported in this study.

Acknowledgements: The authors would like to thank and appreciate Tertiary Education Trust Fund (TETFund), Nigeria for giving financial support for the research through Federal University of Lafia, Nasarawa State, Nigeria. Engr. Tijani Idowu Abdulfatah of Integrated Research Laboratories located in Tanke, Oke–Odo, Ilorin, Kwara State, Nigeria is also appreciated for the total lipids and phytosterol analyses carried out in his laboratories.

References

[1] Aremu, M. O., Ambo, A. I., Onwuka, J. C., Akpomie, T. E. & Omotehinwa, H. F. (2025). Assessment of fatty acids profile and sugar content of African black pear (*Dacryodes edulis*) kernel and pulp of the fruit. *Bangladesh Journal of Science and Industrial Research*, 60(2), 73–82. https://doi.org/10.37933/bjsir.v60i2.78348

[2] Dogara, S. U. (2022). Nutritional and functional potential of wild and semi-domesticated fruits in North-East Nigeria. *Journal of Food Science and Nutrition*, 8(2), 45–53.

[3] Saber, N., Mohamed, E. & El-Halim, F. (2022). Physicochemical properties and fatty acid composition of underutilised fruit seed oils. *Journal of Food Science and Technology*, 59(9), 3492–3501. https://doi.org/10.1007/s13197-022-05302-0

[4] Ebbo, P., Adamu, H. & Abubakar, M. (2014). Ethnobotanical survey and preliminary phytochemical screening of *Diospyros mespiliformis* in Northern Nigeria. *Journal of Ethnopharmacology*, 154(3), 645–651. https://doi.org/10.1016/j.jep.2014.04.014

[5] Adewuyi, A. & Oderinde, M. S. (2014). Fatty acid composition and physicochemical properties of selected under-utilized seed oils in Nigeria. *Food Chemistry*, 165, 506–510. https://doi.org/10.1016/j.foodchem.2014.05.136

[6] Islam, M. S., Khan, M. A. & Qader, S. (2022). Utilisation of *Hyphaene thebaica* as food and feed in desert and subtropical regions. *Journal of Arid Environments*, 201, 104545. https://doi.org/10.1016/j.jaridenv.2022.104545

[7] AOAC (2006). *Official Methods of Analysis*, 19th edn. Association of Official Analytical Chemists: Washington, DC, USA. Method Validation Programmes. Available. http://www.aoac.org/vmeth.page.1.htm

[8] Saed, A. A. & Isam, M. A. Z. (2018). Phytochemistry and pharmaceutical evaluation of Balanites aegyptiaca: an overview. Journal of Experimental Biology and Agricultural Sciences, 6(3), 453–465. https://doi.org/10.18006/2018.6(3).453.465

[9] Cunha, V. M., da Silva, M. P., de Sousa, S. H., do Nascimento Bezerra, P., Menezes, E. G., da Silva, N. J., da Silva Banna, D. A., Araújo, M. E. & de Carvalho Junior, R. N. (2019). Bacaba-de-leque (*Oenocarpusdistichus* Mart.) oil extraction using supercritical CO2 and bioactive compounds determination in the residual pulp. *The Journal of Supercritical Fluids* 144, 81–90. https://doi.org/10.1016/j.supflu.2018.10.010/

[10] Ekpa, O., Palou, A. & Frangi, A. (2021). Nutritional composition and health-promoting properties of underutilized African plant foods: A systematic review. *Food Chemistry*, 356, 129707. https://doi.org/10.1016/j.foodchem.2021.129707

[11] Gadu, S. R., Alademeyin, J. O. & Abubakar, M. (2020). Fatty acid profile and physicochemical properties of oils extracted from selected wild fruits in West Africa. *Journal of Food Composition and Analysis*, 92, 103589. https://doi.org/10.1016/j.jfca.2020.103589

[12] Kavithaa, V. & Parimalavalli, R. (2014). Physicochemical characteristics and fatty acid composition of underutilized seed oils. *Journal of Food Sci. and Techn.*, 51(9), 1990–1996. https://doi.org/10.1007/s13197-012-0738-1

[13] Atasie, V. N., Akinhanmi, T. F. & Ojiodu, C. C. (2009). Proximate analysis and physico-chemical properties of *Aframomummelegueta* and *Monodoramyristica* seeds. *Journal of Medicinal Food*, 12(2), 393–397. https://doi.org/10.1089/jmf.2007.0642

[14] Okwu, D. E. & Ukanwa, N. H. (2010). Nutritive value and phytochemical contents of wild fruits used in Nigerian traditional diets. *African J. of Biotechnology*, 9(25), 3807–3810. https://doi.org/10.5897/AJB10.1239

[15] Aremu, M. O. & Ibrahim, H. (2019). Variability in fatty acid composition of selected Nigerian wild fruits. *Journal of Food Composition and Analysis*, 84, 103252. https://doi.org/10.1016/j.jfca.2019.103252

[16] Mbanga, J. N. & Nkang, A. (2021). Comparative study of fatty acid composition in indigenous African fruit seed oils. *African Journal of Food Science*, 15(3), 85–93. https://doi.org/10.5897/AJFS2020.2048

[17] Gunstone, F. D. (2011). *Vegetable Oils in Food Technology: Composition, Properties and Uses* (2nd ed.). Wiley-Blackwell.

[18] Tetteh, G. & Asare, R. (2022). Unsaturated fatty acid profiles and health implications of oils from under-utilised African tree species. *Food Research International*, 162, 111923. https://doi.org/10.1016/j.foodres.2022.111923

[19] Aremu M. O., Ibrahim H. & Aremu S. O. (2016), Lipid composition of black variety of raw and boiled tigernut (*Cyperus esculentus* L.) grown in North-East Nigeria, *Pakistan Journal of Nutrition* 15(5), 427–438. https://doi.org/10.3923/pjn.2016.427.438

[20] Yusuf, F., Adeyemi, M. & Olaniyi, O. (2020). Variability in fatty acid content of indigenous Nigerian fruit seed oils. *Journal of Food Composition and Analysis*, 89, 103466. https://doi.org/10.1016/j.jfca.2020.103466/

[21] Hassan, M. K., Adeoye, O. & Oladimeji, F. (2021). Fatty acid profile of *Detarium senegalense* kernel oil from Nigeria. *Journal of Food Bio-chemistry*, 45(5), e13758. https://doi.org/10.1111/jfbc.13758

[22] Nkafamiya, I. I., Jideani, A. I. O. & Jideani, V. A. (2010). Fatty acid profile and other physico-chemical properties of Shea (*Vitellaria paradoxa*) kernel oil. *International Journal of Agricultural Research*, 5(2), 99–105. https://doi.org/10.3923/ijar.2010.99.105

[23]. Olaleye, M. T., Adejobi, F., & Ayodele, O. O. (2022). Potential of wild melon and roselle seed oils as nutraceutical raw materials: Fatty acids and antioxidant properties. *Journal of Food Processing and Preservation*, 46(3), e16324.https://doi.org/10.1111/jfpp.16324

[24] Garaffo, M., Vassallo-Agius, R., Nengas, Y., Lembo, E., Rando, R., Maisano, R., Dugo, G. & Giuffrida, D. (2011). Fatty acids profile, atherogenic and thrombogenic health lipid indices of raw roe of bluefin tuna and its salted product "bottarga." *Food and Nutrition Sciences*, 2(7), 736–743. https://doi.org/10.4236/fns.2011.27101/

[25] Chinwe, A. N., Theresa, O. O. & Dorothy, C. A. (2024). Assessment of physicochemical and fatty acid properties of oils extracted from avocado pear (*Persea americana*) and African black pear (*Dacryodes edulis*). *IPS Journal of Agriculture, Food Technology and Security*, 1(1), 20–25.

[26] Osagie, A. U., Eke, N. B. & Ofuya, Z. D. (2021). Fatty acid composition and physicochemical properties of African pear oil: Nutritional and health implications. *Journal of Nutritional Biochemistry*, 8(6), 108–114.

[27] El-Kholy, W. M. (2018). Nutritional importance of *Hyphaene thebaica* fruit. *Journal of Food Measurement and Characterization*, 12, 256–264. https://doi.org/10.1007/s11694-017-9620-1

[28] Djuuričić, D. & Calder, P. C. (2021). Omega-3 fatty acids and cardiovascular health: An update for health professionals. *Nutrients*, 13(7), 2332. https://doi.org/10.3390/nu13072332

[29] Bora, P. S., Narain, N. & Rocha, R. V. M. (2022), Chemical characterization and nutritional analysis of avocado (*Persea americana* Mill.) oil. *J. of the Am. Oil Chemists' Society*, 99(3), 123–134. https://doi.org/10.1002/aocs.12613

[30] Usman, Z. L., Aremu, M. O., Ogah, S. P. I., Ibrahim, H. & Aremu, S. O. (2024). Physicochemical characteristics and fatty acid composition of five selected leafy vegetables grown in southwest, Nigeria. *J. of Human, Health and Halal Metrics*, 5(2), 33–45. https://doi.org/10.30502/jhhhm.2024.473108.1095

[31] Russo, A. (2009). The unsaturated: Saturated fatty acid ratio in the food supply and risk of cardiovascular disease. *Nutrition Reviews*, 67(11), S19–S22. https://doi.org/10.1111/j.1753-4887.2009.00200.x

[32] Santos-Silva, J., Bessa, R. J. B. & Oeztuerk, C. (2002). Effect of diet and exercise on hypocholesterolaemic/hypercholesterolaemic index of fats in animal models. *Food Chemistry*, 76(2), 213–220. https://doi.org/10.1016/S0308-8146(01)00261-3

[33] Simopoulos, A. P. (2020). The importance of the ω-6/ω-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Experim. Biology and Medicine*, 245(5), 467–479. https://doi.org/10.1177/1535370220916303

[34] Aremu, M. O., Awagulu, M. S., Ayakeme, E. B., Zando, C., Bini, M. E., Omosebi, M. O. & Aremu, D. O. (2022). Lipid profile and health attributes of mango (*Mangifera indica* (L.) seed kernel and cashew (*Anarcadium occidentale* L.) nut kernel: A comparative study. *Journal of Human, Health and Halal Metrics*, 3(2), 14–22. https://doi.org/10.30502/jhhhm.2022.364887.1061

[35] Kapcsándi, V., Lakatos, E. H., Sik, B. & Székelyhidi, R. (2021). Characterization of fatty acid composition, antioxidant capacity, and nutritional value of oils from various grape seed varieties (*Vitis vinifera*). *OCL – Oilseeds and Fats, Crops and Lipids*, 28(3), D301. https://doi.org/10.1051/ocl/20210025/

[36] Ulbricht, T. L. V. & Southgate, D. A. T. (1991). Coronary heart disease: Seven dietary factors. *The Lancet*, 338(8773), 985–992. https://doi.org/10.1016/0140-6736(91)91846-M/

[37] Qian, Y., Wojciechowska, P., Siger, A., Kaczmarek, A. & Rudzińska, M. (2018). Phytochemical content, oxidative stability, and nutritional properties of unconventional cold-pressed edible oils. *J. of Food and Nutr. Res.*, 6(7), 476–485. https://doi.org/10.12691/jfnr-6-7-9

[38] Kiin-Kabari, D. B., Umunna, P. S. & Giami, S. Y. (2020). Physicochemical properties and fatty acid profile of African elemi (*Canarium schweinfurthii*) fruit pulp oil compared with palm kernel oil. *European Journal of Agriculture & Food Science*, 2(6), DOI: 10.24018/ejfood.2020.2.6.149

[39] Hassan, M. K., Adeoye, O. & Oladimeji, F. (2021). Fatty acid profile of *Detarium senegalense* oil. *Journal of Food Biochemistry*, 45(5), e13758.

[40] Dadazadeh, A., Azadmard-Damirchi, S., Piravi-Vanak, Z., Torbati, M. & Martinez, F. (2025). Extraction of oil from *Allium iranicum* seed and evaluation of its fatty acid profile and health lipid indices. *Foods*, 14(9), 1483. https://doi.org/10.3390/foods14091483

[41] Omeje, K. O., Iroha, G. O. & Okorie, E. U. (2022). Biochemical characterization of Soxhlet-extracted pulp oil of *Canarium schweinfurthii*. *Journal of Food Science & Technology*, 59, 3567–3578. https://doi.org/10.1007/s13197-022-05378-2

[42] Giovagnoli-Vicuña, C., Viteri, R., Aparicio, J., Quispe, I. & others. (2025). Bioactive properties and fatty acid profile of seed oil from *Amomyrtus luma*. *Compounds*, *5*(3), 31. https://doi.org/10.3390/compounds5030031

[43] Wapid, R. (2017). Phytochemical and nutritional properties of seed oil from under-utilised fruits: the case of cape gooseberry (*Physalis peruviana*). *Natural Product Research*, 31(12), 1353–1361. https://doi.org/10.1080/14786419.2016.1230540/

[44] Aremu, M. O. & Amos, V. A. (2010). Fatty acids and physicochemical properties of sponge luffa (*Luffa cylindrica*) kernel oils. *Int. J. Chem. Sci*., 3(2), 166 – 171.

[45] Moreau, R. A., Whitaker, B. D. Hicks, K. B. (2002). Phytosterols, phytostanols, and their conjugates in foods: Structural diversity, quantitative analysis, and health-promoting uses. *Prog. Lipid Res*., 41(6), 457-500. http://dx.doi.org/10.1016/S01637827(02)00006-1

[46] Aremu, M. O., Ibrahim, H. & Andrew, C. (2017). Comparative studies composition of on the lipid blood plum (*Haematostaphis barteri*) pulp and seed oils. *The Open Biochemistry Journal*, 6(5), 73–80. https://doi.org/:10.2174/1874091X01711010094

Citing this Article

Aremu, M. O., Ezekiel, E., Usman, A., Ambo, I. A., Onwuka, J. C., & Muhammad, H. I. (2026). Fatty acid profiles, physicochemical characteristics and phytosterols of three underexploited fruit kernels and pulps from North-East, Nigeria. *Lafia Journal of Scientific and Industrial Research*, *4*(1), 55–62. https://doi.org/10.62050/ljsir2026.v4n1.700