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Physicochemical Properties of Okra (*Abelmoschus esculentus* (L.) Moench) Seed Oil: A Comparative Assessment with Prominent Edible Oils Available in Nigeria

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ABSTRACT

Plant-derived oils have been extensively investigated over several decades owing to their diverse nutritional, industrial, and therapeutic applications. These oils are typically extracted from seeds using established techniques, including Soxhlet extraction and contemporary methods employed in research environments. Okra (*Abelmoschus esculentus* (L.) Moench), a member of the Malvaceae family, is a widely cultivated vegetable with significant nutritional and commercial value. Okra seeds exhibit a substantial oil content ranging from 20 to 40 %, positioning them as a viable resource for the expanding edible oil sector in Nigeria and globally. The primary aim of this study was to evaluate the physicochemical properties of okra seed oil through a comparative assessment with prominent edible oils available in Nigeria. Standard analytical protocols were utilized to assess key parameters for okra seed oil, yielding the following values: yield (17.4% w/w) acid value (AV) (15.87 ± 0.00 mg KOH/g), saponification value (SV) (196.89 ± 0.01 mg KOH/g), refractive index (1.47 ± 0.00), specific gravity (0.91 ± 0.00), iodine value (IV) (70.95 ± 0.01 g I_2/100 g), peroxide value (PV) (1.32 ± 0.01 meq O_2/kg), pH (6.45 ± 0.01), and free fatty acid content (7.98 ± 0.00%). Although okra seed oil exhibited favourable saponification and low peroxide values, indicating good functional and oxidative stability, its elevated acid value indicates significant hydrolytic degradation and renders the crude oil unsuitable for direct consumption without refining. Nonetheless, the oil's physicochemical profile, particularly its high saponification and moderate unsaturation, supports its suitability for industrial uses (e.g., soap and cosmetic manufacture) and, subject to appropriate refining and quality control, for edible markets; with targeted processing and value-chain development, it therefore has economic potential.

Keywords: Okra, Seed oil, Soxhlet extraction, Physicochemical, Edible Oil

Introduction

Okra (*Abelmoschus esculentus* (*L.*) Monech), belonging to the Malvaceae family, is a widely cultivated vegetable with nutritional and industrial applications. It originated from Ethiopia and is widely cultivated in both tropical and subtropical areas. *A. esculentus* is commonly called "lady's finger", and it serves a wide range of purposes due to various uses of the pods, fresh leaves, buds, flowers, stems, and seeds (Gerrano, 2018). Okra seed oil is a potential source of edible oil with high levels of unsaturated fatty acids and bioactive compounds. It is also rich in fatty acids like oleic and linoleic (Kantar *et al.,* 2024). Okra is also a high source of protein (Gemede *et al.,* 2015). It also includes palmitic acid (6.85-19.83%) and stearic acid (3.00-5.31%)

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as major saturated fatty acids (Anwar *et al*., 2020 & Akinoso *et al*., 2023).

Globally, the crucial role of oil crops in human health cannot be overemphasised, as humans need fats. The daily energy requirement for man consists of about 25%-35% fats, including essential fatty acids and fat-soluble vitamins (Meijaard *et al*., 2024). Vegetable oils have been extracted from plant seeds and fruits for several decades, with rapeseed, soybean, sunflower, palm, and coconut oil being the major sources of oil globally. Studies have shown the benefits of oils from plants as they are used in the management and cure of diseases such as obesity, diabetes, and hypertension, amongst others (Ferrentino *et al.,* 2020). Several natural oils are known for their antibacterial, relaxant, stimulating, anti-depressant, therapeutic and fungicidal properties (Okunade & Fatoye, 2024).

The values and properties of vegetable oils are estimated using physicochemical parameters such as colour, odour, density, and saponification value (Sowunmi *et al.,* 2025). Also, the quality, yield and viability of vegetable oils depend on the extraction method employed. For many decades, a series of techniques have been developed towards optimising oil yield and preserving bioactive components and in the same way, minimizing environmental effects. The Soxhlet extraction method was introduced by Franz Von Soxhlet in 1879. This method focuses on successive solvent recycling, leading to efficient and exhaustive oil extraction from plant products (Azwanida, 2015). Recently, new techniques such as ultrasound-assisted extraction (UAE), superficial fluid-extraction (SFE), microwave-assisted extraction (MAE), and enzymatic extraction have been employed due to their improved oil yield ability and compound preservation. However, the Soxhlet extraction method remains the benchmark for estimating extraction processes in research settings (Abdulkareem *et al.,* 2021).

The consumption of *A. esculentus* has played vital roles in food security and poverty alleviation, but has, however, gained less attention as it has been considered a minor crop. Recently, the demand for vegetable oils is rapidly increasing, therefore giving opportunities for underutilised vegetable oil sources. Currently, the production value of vegetable oils has been estimated at over US$265 billion annually (Meijaard *et al*., 2024). Okra seed oil has a high amount of oil content (20%-40%) (Aminu *et al*., 2019), thereby making it a promising source in the fast-expanding oil industry in Nigeria and the world at large. Thus, this study aims to comprehensively evaluate the physicochemical quality of okra seed oil extracted via a standard method and benchmark it against the quality specifications of established edible oils in Nigeria.

2.0 Materials and Method

Sample Collection and Preparation

Fresh okra fruits (*Abelmoschus esculentus*) were purchased from Akungba Market, Akungba-Oke, Ondo State, Nigeria. The material is reported as a locally cultivated landrace of *A. esculentus*. The fruits were transported to the laboratory on the same day and placed in a shaded, well-ventilated room for air-drying. Drying was performed on raised trays in a single layer at ambient laboratory temperature (25-30 °C) for 14 days; the material was turned every 48 h to promote even drying and to reduce mould growth. After drying, pods were opened manually, seeds separated, and seeds milled to a fine powder. The seed powder was stored in airtight amber polythene bags at 4 °C until extraction.

Experimental

Approximately 100 g of dried, milled okra seed powder was placed in a cellulose thimble and loaded into a Soxhlet extractor. n-Hexane (500 mL; bp ≈ 69 °C) was used as the extraction solvent. A few anti-bumping granules were added to the boiling flask to prevent bumping. The assembly was heated to the solvent boiling point and run for 6 h; heating was adjusted to give an average siphon (reflux) rate of ≈4-6 cycles h^{-1}, monitored visually. Extraction was considered complete when the condensed solvent siphoning back into the thimble ran colourless and the defatted residue, when oven-dried at 105 °C, showed no further loss in mass.

The hexane-oil solution was filtered and solvent removed on a rotary evaporator (bath temperature 40 °C; reduced pressure ~200-300 mbar). The

recovered oil was dried over anhydrous Na_2SO_4, re-filtered, briefly flushed with nitrogen to minimise dissolved oxygen, and transferred to amber glass vials for storage at 4 °C until analysis. (Gbadamosi *et al*., 2020). Extractions were performed in duplicate, and the mass of oil recovered from each run was recorded.

Physicochemical Characteristics of Oil

The physicochemical properties of the oil: Acid value (AV), Saponification value (SV), Refractive index, Specific gravity, Iodine value (IV), and Peroxide value (PV) were analysed according to the methods described by the American Oil Chemists' Society (AOCS, 1993).

Determination of Acid Value

The acid value was determined by weighing 5g of the oil sample into a conical flask, and dissolved in 10mL of neutralised diethyl ether : ethanol mixture (1:1 v/v). Complete dissolution was ensured by gentle swirling and 1-2 minutes of ultrasonic agitation. Two drops of phenolphthalein indicator were added, and the solution was titrated against 0.1 molar potassium hydroxide (KOH) solution until a persistent pink end-point was observed for about 30 seconds. A reagent blank was run concurrently, the process was repeated twice, and the average was calculated using equation (1):

$$Acid\ value = \frac{V \times M \times 56.10}{Weight\ of\ extracted\ oil} \qquad (1)$$

Where: V = volume (mL) of KOH used in the titration; M = molarity of KOH solution (O.1 M).

Determination of Saponification Value

1g of the oil sample was weighed in the conical flask. 25 mL of potassium hydroxide (KOH) was added to the mixture and left in the water bath to boil for 1 hour. Then 3 drops of phenolphthalein indicator were added to the hot sample and titrated against 0.5 M hydrochloric acid (HCL). The solution turned pink and then yellow. Blank was prepared, and the process was repeated. The saponification value was calculated using equation (2):

$$Saponification\ value = \frac{(B - S) \times N \times 56.1}{Weight\ of\ extracted\ oil} \qquad (2)$$

Where: B = volume (mL) of HCL in blank; S = volume of HCL in sample; N = normality of HCL (0.5 M).

Determination of Refractive Index

The refractive index of the sample was measured using an Abbé refractometer. The prism was cleaned with acetone. A small amount of the sample was dropped on the prism, and the slide was covered. This was viewed by adjusting the control knob through the telescope (eye piece) to give a dark and light spot. Then the reading was taken. This procedure was repeated, and the average result was obtained. Refractive index was calculated using equation (3).

$$R = R_1 + K(T - T_1) \qquad (3)$$

R = Reading reduced to STP, R1 = Reading obtained from refractometer, K = Constant of proportionality, T = Absolute temperature (℃), T1 = Ambient temperature (℃)

Determination of Specific Gravity

The oil sample was melted in a plate. The weight of the specific gravity bottle was recorded as W_1. The S.G bottle was later filled with water, and the weight was recorded as W_2. The bottle was refilled again with oil, and the weight was recorded as W_3 and the specific gravity was calculated using equation (4).

$$Specific\ gravity = \frac{(W_3 - W_1)}{(W_2 - W_1)} \qquad (4)$$

W_1 = Weight of bottle, W_2 = Weight of water and bottle, W_3 = Weight of sample and bottle

Determination of Iodine value

0.2 g of the oil sample was weighed in a conical flask, and 10 mL of carbon tetrachloride (CCL_4) was added to the sample. 10mL of Wij's solution was then added to the mixture and kept in the dark for 30 minutes at room temperature. 10ml of KI solution and 50 mL of water were added to the solution and titrated against 0.1M of sodium thiosulphate ($Na_2S_2O_3$) in a burette. 3 drops of starch were added as an indicator and shaken continuously until the blue-black colour disappeared and became clear. A blank titration was performed simultaneously. The iodine value was calculated using equation (5).

$$Iodine\ value = \frac{126.9 \times M \times (B-A)mL}{\text{Weight of sample}} \quad (5)$$

126.9 = molecular weight of iodine, M = molarity of $Na_2S_2O_3$, B = blank titre value, A = titre value

Determination of Peroxide Value

1.045 g of oil was weighed into a stoppered conical flask, and 30 mL of acetic acid:chloroform (3:2 v/v) was added. The mixture was stirred until the oil was fully dissolved. 1.0 mL of saturated potassium iodide (KI) solution was added, the flask was immediately stoppered, and the contents were allowed to react in the dark for 1 minute (no heating or boiling). After reaction, 20 mL of distilled water was added, and the liberated iodine was titrated with 0.01 M sodium thiosulfate ($Na_2S_2O_3$) using starch as an indicator; titration continued until the blue-black colour disappeared. A blank titration was performed under the same conditions. The peroxide value (meq O_2/kg) was calculated using equation (6).

$$Peroxide\ value = \frac{(V1-V2)mL \times M \times 100}{Weight\ of\ sample} \quad (6)$$

V1= volume of titre value, V2 = volume of blank, M = molarity of $Na_2S_2O_3$

Determination of pH

The pH meter was standardized by inserting the calomel electrode into distilled water, then into buffer solutions 4 and 9. After the pH meter had been standardized, it was inserted into the sample, and the reading was taken.

Data Analysis

Data were presented using descriptive statistics, and results were expressed as mean ± SD.

Results and Discussion

The oil extracted from the dried okra seeds (yield 17.4% w/w) is a light, yellowish, and slightly acidic oil similar to the conventional seed oils such as cottonseed oil and soybean oil. Table 1 shows the chemical and physical characteristics of Okra seed oil as determined from the experiment.

The saponification value of the okra seed oil obtained in this study is 196.89 mg KOH/g, which falls within the expected range (195 – 205 mg KOH/g) for edible oils as specified by the Standard Organization of Nigeria (SON, 2000). From Table 2, the saponification value of the okra seed oil is higher than that of sunflower seed oil (132 and 182 mgKOH/g) as reported by Aboki *et al*., (2012), and Ologunde *et al*., (2008), respectively and cashew nut seed oil (137 and 168 mgKOH/g) according to Aremu *et al.,* (2006,) Evbuowman *et al.,* (2013) and Aremu and Akinwumi, (2014.) However, this result generally indicates that okra seed oil may be useful in the production of liquid soap and shampoo in the cosmetics industry only after refining for better quality parameters.

Peroxide value determines the level of rancidity the oil has undergone. The peroxide value obtained in this study is 1.32 meq/kg. Low peroxide value of the okra seed oil indicates freshness, high resistance to peroxidation and low rate of spoilage. Okra seed oil has a lower peroxide value compared to cashew nut seed oil (10 meq/kg) and palm kernel seed oil (13.40 meq/kg) as reported by Aremu and Akinwumi (2014) and Obgunugafor *et al*. (2011), respectively. High peroxide values in some oils might be due to the effect of frying temperatures or exposure to light, thereby causing destruction of some glycosides in the oil (Gbadamosi *et al*., 2020).

Acid value indicates whether the oil is in a good, non-degradable state or not. This value is recommended to be less as high values can indicate rancidity and quality reduction (Ichu and Nwakanma, 2019). In this study, the acid value is high compared with sunflower oil (0.95 mgKOH/g) and groundnut oil (4.63 mgKOH/g) as reported by Aboki *et al*. (2012) and Amos-Tauta and Onigbinde (2013), respectively. The oil's acid value (15.87 mg KOH/g; FFA ≈ 7.98%) is well above commonly accepted limits for edible oils (often cited ≈ ≤4 mg KOH/g) and therefore indicates pronounced hydrolytic rancidity rather than primary oxidative spoilage. Such elevation in AV/FFA is most plausibly explained by hydrolytic cleavage of triglycerides driven by residual moisture and endogenous lipase activity during the uncontrolled post-harvest interval, seed damage or microbial action, conditions known to accelerate FFA formation (Gbadamosi et al., 2020; Emebu et al., 2022; Tan et al., 2023). However, the low peroxide value

observed in this study argues that oxidative rancidity is not the principal process at present, supporting hydrolysis as the dominant degradation pathway. Consequently, the crude oil is unsuitable for direct consumption without refining and improvements in handling (e.g., prompt seed separation, controlled/oven drying or blanching, reduced storage time, and immediate extraction) are recommended to limit lipase activity and reduce FFA formation (Kaya and Hung, 2021). Generally, an increase in acid value may be a result of enzyme activity inhibition in the okra seed oil. Zerihum *et al.* (2020) reported that okra seed oil has an acid value of 1.89 mg KOH/g, which is extremely lower than the result reported in this study. This low acid value may be a result of oven drying of the oil extract. This justifies the report by Gbadamosi *et al*. (2019) that the process of heating or frying significantly reduces acid value and free fatty acid content in commercial oil.

Table 1: Physical and chemical properties of Okra seed oil.

Parameters	Values
Acid Value (mg KOH/g oil)	15.87 ± 0.00
Saponification Value (mg KOH/g oil)	196.89 ± 0.01
Refractive Index	1.47 ± 0.00
Specific Gravity	0.91 ± 0.00
Iodine Value (g/100g oil)	70.95 ± 0.01
Peroxide Value (mEq O_2/Kg)	1.32 ± 0.01
pH	6.45 ± 0.01
Free fatty acids	7.98 ± 0.00

Values are mean ± SD of triplicate determinations.

Table 2: Physicochemical properties comparison between okra (*Abelmoschus esculentus*) oil and other highly classified edible oils in Nigeria.

Seeds and Parameters	SV	PV	AV	IV	SG	RI	FFA	References
Okra seed oil	187.29	3.91	35.99	115.03	NR	NR	NR	Dong *et al*., 2014
Cashew nut seed oil	168.30	3.10	0.82	44.10	0.964	1.654	28.40	Aremu *et al.,* 2006
	137.00	7.95	10.70	41.30	0.962	1.458	5.40	Evbuowman *et al.,* 2013
	167.00	10.00	2.62	87.77	0.913	1.730	2.45	Aremu and Akinwumi, 2014
Soybean seed oil	228.9	NR	19.21	73.02	NR	1.466	9.66	Amos-Tauta and Onigbinde, 2013
	187.1	0.53	0.304	133.17	NR	1.469	0.313	Wazed *et al*., 2023
Palm kernel seed oil	249.90	4.36	10.71	20.70	0.910	NR	5.90	Evbuowman *et al*., 2013
	210.50	13.40	6.20	34.74	NR	1.473	3.12	Ogbunugafor *et al*., 2011
	198.2	1.05	0.94	44.82	NR	NR	NR	Hasan *et al*., 2016
	202.39	2.21	0.878	46.18	NR	1.453	0.502	Wazed *et al*., 2023
Sunflower seed oil	188.51	0.89	NR	78.45	0.921	1.471	0.22	Ologunde *et al*., 2008
	182.14	6.32	0.95	119.92	0.915	NR	0.042	Aboki *et al*., 2012
Groundnut oil	227.49	NR	4.63	38.65	NR	1.462	2.33	Amos-Tauta and Onigbinde, 2013
	201.00	0.74	2.35	110.70	NR	0.247	1.18	Ayoola and Adeyeye, 2010
	175.78	NR	1.88	95.87	0.914	NR	0.94	Musa *et al*., 2012

SV = Saponification Value, PV = Peroxide Value, AV = Acid Value, IV = Iodine Value, SG = Specific Gravity, RI = Refractive Index, FFA = Free Fatty Acid, NR = Not Recorded.

Iodine value measures the extent of unsaturation of free fatty acids available in the oil and determines oil stability to oxidation. This study also reveals the iodine value of okra seed oil as 70.95 as compared with sunflower, groundnut oil and soybean oil at a similar range. This suggests a moderately unsaturated oil. Okra seed oil has a higher degree of unsaturated and better oxidative stability compared to groundnut oil (Anwar *et al*., 2020). Since the iodine value is lower than 100, it may be classified as a non-drying oil.

The specific gravity of the okra seed oil in this study was related to the standard range (0.898 – 0.907 g/ml) approved by the standard organization of Nigeria (SON, 2000). The specific value (0.91) presently obtained for okra seed oil shows that it is less dense than water, and this value is consistent across other compared oils. The refractive index of the okra seed oil was 1.47, which is also similar in value to other edible oils. free fatty acid value of 7.98. This study revealed that okra seed oil has a free fatty acid value of

7.98, slightly higher than sunflower oil and groundnut oil.

Conclusion

In this study, various physicochemical parameters of okra seed oil were investigated. The results showed significant similarities and major differences in value when compared with other major oils in Nigeria. This study concludes that the okra seed oil extracted under the described conditions exhibited an unacceptably high acid value and free fatty acid content, indicating severe hydrolytic rancidity likely due to post-harvest seed handling or processing. While other parameters (PV, IV, SV) were within typical ranges, the oil's high FFA precludes its direct use as an edible oil without significant refining. Future work must focus on immediate post-harvest processing (drying, inactivation of lipases) to preserve oil quality.

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Conflict of Interest

The authors declare no conflict of interest.

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