JOURNAL OF AGRICULTURAL ECONOMICS, EXTENSION & SCIENCES
Official Journal of the College of Agricultural Economics and Extension
www.jaees.org
www.uam.edu.ng
Jaees Vol. 14 No. 2 2026, Page 194-204
ISSN (Print) 2545-5179, ISSN (Online) 2714-5018

APPLICATION OF DIFFERENT ROASTING TEMPERATURES ON THE YIELD, FATTY ACID PROFILE AND ANTIOXIDANT POTENTIAL OF *UGBA* SEED OIL

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Abstract

This study evaluated effects of different roasting temperatures on the yield, fatty acid profile, antioxidant properties and antioxidant activities of Ugba seed oil. Ugba seeds obtained from commercial stockers in a local market were sorted, cleaned, sliced and roasted at 100°C, 115°C, 130°C, 145°C and 160°C for 15 min, while unroasted seeds served as the control. The roasted seeds were milled, and oil was extracted from each sample by Soxhlet extraction using food-grade n-hexane. Extracted oils were evaluated for yield, fatty acid profile, antioxidant properties and antioxidant activities. Data were analysed using one-way ANOVA at 95% confidence interval. Oil yield increased from 25.22 to 48.23% with increasing roasting temperature. Oil from unroasted seeds contained 12 fatty acids, compared with 13 fatty acids in oils from seeds roasted at 100°C, 115°C and 145°C, and 14 fatty acids at 130°C. Lauric, myristic, palmitic and stearic acids were the major saturated fatty acids, while oleic and linoleic acids predominated among unsaturated fatty acids. Saturated fatty acids increased, whereas mono- and polyunsaturated fatty acids decreased with increasing roasting temperature. Total flavonoid content ranged from 0.87 to 2.91 CE mg/g, while total phenolic content ranged from 12.06 to 14.44 mg GAE/100 g. Antioxidant activities increased with roasting temperature, with DPPH ranging from 54.75 to 67.90%, FRAP from 3.52 to 4.92 µg/ml, and ABTS from 46.27 to 55.96%. Overall, roasting enhanced oil yield, antioxidant properties and antioxidant activities, while modifying the fatty acid profile.

Keywords: *Ugba seed oil, roasting temperature, oil yield, fatty acid profile, antioxidant activity.*

1.0 Introduction

Edible vegetable oils are important components of the human diet and serve as concentrated sources of energy, essential fatty acids and lipid-soluble bioactive compounds (Geng *et al.,* 2023). Beyond their nutritional functions, vegetable oils are increasingly being recognized as sources of naturally occurring antioxidants and other phytochemicals that may contribute to the stability and functional quality of foods (Gilbraith *et al.,* 2021). Consequently, research interest has shifted towards underutilized oilseeds with potential for producing nutritionally valuable and technologically useful edible oils. One such indigenous oilseed is the *Ugba* (*Pentaclethra macrophylla* Benth.), a multipurpose leguminous tree widely distributed in the humid regions of West and Central Africa, particularly Nigeria (Ghafoor *et al.,* 2020).

The *Ugba* seed is traditionally consumed in several forms, especially after fermentation, and is commonly associated with the production of African salad called "ugba'', a popular food in southeastern Nigeria (Onyekachi *et al.,* 2021). Although the seed contains considerable amounts of oil, protein and other nutrients, its potential as an important source of edible vegetable oil remains comparatively underexploited (Kumar *et al.,* 2021). The oil fraction contains predominantly unsaturated fatty acids, including oleic and linoleic acids, together with minor constituents that may contribute to its nutritional and antioxidant properties. The chemical composition of *Ugba* seed oil, however, can be influenced by cultivar, geographical origin, maturity, extraction procedure and, importantly, processing conditions (Salama *et al.,* 2019).

Roasting is one of the traditional and technological treatments applied to oilseeds before oil extraction. It involves exposing seeds to elevated temperatures for a defined period, resulting in a series of physical and biochemical changes within the seed matrix (Salama *et al.,* 2018). During roasting, moisture is removed, cellular structures may be disrupted, and the accessibility of intracellular oil can increase, potentially improving oil recovery (Arab *et al.,* 2022). Thermal treatment can also promote the formation of desirable volatile compounds and modify the sensory characteristics of the resulting oil (Shingawa *et al.,* 2018). Therefore, roasting has considerable potential as a simple processing intervention for improving the extractability and quality of *Ugba* seed oil.

Ugba seed is a largely underutilize oilseed crop in Nigeria capable of massively contributing to the edible oil sector of the country if its potential is fully explored. Top industries have consistently overlooked this oil crop with high oil yield for the popular oilseeds like soybean, peanut etc. The high dependency of these popular oilseeds has over the years proven insufficient to meet the growing domestic demands, hence the need to import, a practice currently harming our economy. Exploiting our local crop *Ugba* seed for oil production is hereby necessary. More so, as an oilseed, *Ugba* seed oil has been reported to contain high level of unsaturation (Onwuzuruike *et al.,* 2024). Its unsaturation level affects it stability and suitability for different food applications, as well as promote oxidative rancidity. Subjecting *Ugba* seed oil to pre-treatment method capable of increasing the oil yield and improve stability is of paramount importance. Previous studies have investigated various means through which the stability and *Ugba* seed oil properties can be improved. Some of these studies include blending procedure (Onwuzuruike *et al.,* 2024), gamma irradiation applications (Ifeoluwa *et al.,* 2014) amongst others but not roasting pre-treatment. It is therefore important to investigate the impact of roasting on the properties of *Ugba* seed oil.

2.0 Materials and methods

2.1 Source of raw materials

Ugba seeds were sourced from Ahia Orie Ntigha in Isiala Ngwa North Local Government Area, Abia State. Thermal processing was carried out at the Food Science and Technology Laboratory, Michael Okpara University of Agriculture, Umudike (MOUAU) while extraction was done using Soxhlet apparatus and was carried out at the National Root Crop Research Institute. All reagents were of analytical grade.

2.2 Roasting of *Ugba* seeds at different temperatures

The method described by Simsek *et al.* (2015) was modified and adopted for roasting the *Ugba* seeds. One kilogram of *Ugba* seeds were sorted, dehulled, sliced into strips (2 x 6 mm) and divided into six (6) portions. Each of the six portions was spread on an aluminum tray as a single layer and roasted by placing into an electric oven (Gallenkemp, 300 Plus, England) set at 100, 115, 130, 145 and 160 °C for 15 min respectively. The seeds were stirred every 2 min using a wooden spatula, to achieve uniform roasting. Following roasting, the strips were removed from the oven and allowed to cool to ambient temperature.

2.3 Extraction of edible oil from roasted *Ugba* strips

Roasted *Ugba* strips were milled in an attrition mill (Model: SK-30-SS, USA) to obtain roasted *Ugba* seeds powder for oil extraction. Soxhlet extraction method was used to extract oil from *Ugba* seed powder. Three hundred and fifty milliliters (350 ml) of n-hexane were first introduced into a 500 ml round bottom flask. *Ugba* seed powder (100 g) was measured into thimbles and inserted at the center of the Soxhlet extractor. The extractor was heated to 65°C for 8 h and was held at that temperature during the extraction process. The extract was removed from the set-up, and transferred to a rotary evaporator (Model: Rotavapor R-300, Switzerland) to recover the solvent, leaving the extract behind. The oil sample was weighed and packaged in an airtight amber bottle until needed for analysis.

2.4 Oil yield determination

The percentage yield of the oils was calculated using the equation by Adepoju *et al.* (2019):

$$oil\ yield\ (\%) = \frac{W_o}{W_s} \times 100$$

Where Wo = mass of oil extracted (g) and Ws = mass of the seed (g).

2.5 Fatty acid profile determination

The fatty acid composition of each oil sample was determined using the gas chromatography (Interscience Thermo Focus GC (Interscience, Louvain-la-Neuve, Belgium) equipment, equipped with column (Capillary, WCOT CP-Sil 88; 60 mL x 0. 25 mm x 0. 20 μm). The detector was Flame Ionization Detector (FID), while the mobile phase used was helium. Preparation of the samples for analysis was done by adding three drops of each oil sample into a test tube followed by the addition of 9 ml hexane and 1 ml of 2 N methanolic potassium hydroxide solution. The tube was closed and shake properly for few seconds. The transesterification of the esters caused by the methanolic potassium hydroxide solution creates the fatty acid methyl esters that were extracted by the hexane. Exactly 1 ml of the solution was withdrawn from the test tube and introduced into the GC vials. The samples were loaded into the GC autosampler AS 3000 trays. Unroasted *Ugba* seed oil (I ml hexane in the GC vial) was placed in the first position. Conditions of analysis include: maximum oven run time, 260°C; inlet temperature, 230°C; injector: split mode; inlet split flow, 60 ml/min; pressure, 5 kPa; constant flow at 1.0 ml/min; sample volume, 1 μl; detector base temperature, 250°C. The analyses were performed in duplicates. Identification of fatty acids was performed by subjecting the chromatogram to manual integration and comparing their retention times with reference standards. The results of FAs were expressed as area percentages of total FAMEs (AOCS, 1995).

2.6 Determination of antioxidant properties and activities

Determination of total flavonoid content

The total flavonoid (TF) content was determined by the aluminium chloride colourimetric assay with modifications (Osuagwu and Ihenwosu, 2014). Aliquots of 60 μL of each oil sample were added to 10 mL test tubes containing 2 mL of ethanol. About 150 μL of 5% sodium nitrite solution (5% $NaNO_2$) was added to each mixture and rested for 5 minutes before the addition of 150 μL 10% aluminium chloride (10 % $AlCl_3$). The resulting mixture was then allowed to stay for another 5 minutes before adding 1 mL of 1 M sodium hydroxide (1.0M NaOH) and vortexed for 10 seconds. The absorbance of the aliquot was measured against prepared reagent blank at 510 nm using a UV spectrophotometer (Jenway Vis Spectrophotometer 6305) and the total flavonoid content expressed as catechin equivalent (CE) mg/g on dry mass.

Total phenolic (TP) content determination

The total phenolic content of the oil samples was determined following the method described by Emelike *et al.* (2017). A calibration curve was constructed using various concentrations of gallic acid, including 0.00, 0.25, 0.50, 0.75, and 1 mM, to establish the external calibration. To measure

the phenolic content, each oil sample was diluted with distilled water to a final volume of 3 ml. The mixture was then stirred for 3 minutes with 0.5 mL of Folin- Ciocalteu reagent. Next, 2 ml of 20 % (w/v) sodium carbonate solution was added. The resulting solution was incubated at room temperature (30.2°C) for 60 min. The absorbance of the solution was measured at 760 nm using a UV/VIS Spectrophotometer (Thermo Scientific Co. Inc., USA). The total phenolic content was quantified using a calibration curve and expressed as gallic acid equivalent per milligram of oil (mg GAE/ 100 g oil).

Determination of antioxidant activity by DPPH assay

The antioxidant activity by DPPH assay was determined using the modified method of Ruslan *et al.* (2018). Each oil sample (2 mL) was added to 2 mL of DPPH solution (50 µg/mL) to initiate the reaction for obtaining a calibration curve. The absorbance at 515 nm was measured after incubation for 30 min by using an ultraviolet (UV)–Vis spectrophotometer (Beckman Coulter DU 720). DPPH (50 µg/mL) was used as the control, ascorbic acid as the standard, and methanol as the blank. Analysis was conducted in duplicate for the standard and the oils. The radical scavenging activity was calculated and expressed as a percentage of the control (free radical solution minus plant extract) using the following formula:

$$\% \text{ Scavenging [DPPH]} = [(A_0 - A_1) / A_0] * 100$$

Where A_0 was the absorbance of the blank (in which the same volume of methanol was used in place of the sample) and A_1 was the absorbance in the presence of the samples or standard (Ascorbic acid).

Determination of antioxidant capacity by FRAP assay

The antioxidant activity by FRAP (Ferric Reducing Antioxidant Power) assay was determined using the modified method of Ruslan *et al.* (2018). FRAP solution was prepared in acetate buffer (pH 3.6). Each oil sample (2 mL) was added to 2 mL of FRAP solution. After incubation for 30 min, the absorbance was read at 593 nm. Ascorbic acid was used as the standard, FRAP (50 µg/mL) as the control, and acetate buffer as the blank. The antioxidant capacity was presented as EC_{50} of FRAP capacity by determining the 50 % exhibitory concentration using the calibration curve.

2.7 Statistical analysis

All experimental data were expressed as mean ± SD (standard deviation). The data were subjected to a one-way analysis of variance (ANOVA) using the SPSS software (version 21, IBM, USA) to determine the significant difference among the experimental data, while Duncan Multiple Range Test (DMRT) method was used to compare the means of experimental data at 95% confidence interval when a significant difference was observed from the One-way ANOVA.

3.0 Results and discussion

3.1 Oil yield of roasted *Ugba* seeds

Oil yield represents the quantity of oil recovered from a given quantity of oilseed and is an important parameter for assessing the suitability of an oilseed for edible oil production and commercial exploitation (Hassan, 2012). The oil yields obtained from the unroasted and roasted *Ugba* seeds at different roasting temperatures are presented in Table 1. The results showed that oil yield ranged from 25.22 to 48.23%, with a significant difference ($p < 0.05$) among the samples. Unroasted *Ugba* seed recorded the lowest oil yield (25.22%), whereas the seed roasted at 160°C recorded the highest yield (48.23%). The progressive increase in oil yield with increasing roasting temperature indicates that roasting enhanced the extractability of oil from the *Ugba* seeds. Specifically, increasing the roasting temperature from 100 to 160°C increased the oil yield from 40.25 to 48.23%, respectively. This improvement may be associated with the disruption of cellular structures during heating, which facilitates the release of oil from the seed matrix and consequently improves solvent penetration and oil recovery during extraction.

The oil yield obtained for the roasted *Ugba* seeds in the present study was comparable to the 47.90% reported by Esther *et al.* (2008), but was higher than the 38.09% reported by Ordu and Yingbo (2021) and the 25.54% reported by Osabor *et al.* (2017). The oil yield of the unroasted sample (25.22%) was comparable to the value of 25.54% reported by Osabor *et al*. (2017), but lower than the values of 47.90% and 38.09% reported by Esther *et al*. (2008) and Ordu and Yingbo (2021), respectively. Such variations in oil yield among studies may be attributed to differences in cultivar or seed variety, geographical and environmental conditions, degree of seed maturity, pretreatment conditions, particle size, extraction solvent, extraction time, extraction temperature, and the specific extraction technique employed.

Furthermore, oilseeds containing more than 25% oil have been considered promising sources of edible oil (Akindele and Nwaboridam, 2018). Since all the *Ugba* seeds in the present study produced oil yields exceeding 25%, the results indicate that the seed possesses considerable potential as a source of vegetable oil for food and possible commercial applications. The substantially higher yield observed at 160°C also suggests that appropriate thermal pretreatment can be employed to improve oil recovery. Nevertheless, excessively high roasting temperatures should be carefully controlled because, although they may increase oil extractability, prolonged or intense heating could adversely affect the chemical quality and oxidative stability of the extracted oil.

Table 1: Oil yield of *Ugba* seeds roasted at different temperatures

Roasted *Ugba* seeds	Oil Yield (%)
100°C	$40.25^{d}\pm0.03$
115°C	$41.43^{c}\pm0.03$
130°C	$42.17^{b}\pm0.02$
145°C	$42.22^{b}\pm0.01$
160°C	$48.23^{a}\pm0.03$
Unroasted	$25.22^{e}\pm0.31$

Results are mean and standard deviation of duplicate determination. Mean with different superscript in the same column are significantly ($p<0.05$) from each other. 100°C = African oil bean seed roasted at 100^0C. 115°C = African oil bean seed roasted at 115^0C. 130°C = African oil bean seed roasted at 130^0C. 145°C = African oil bean seed roasted at 145^0C. 160°C = African oil bean seed roasted at 160^0C. Unroasted = Unroasted African oil bean seeds.

3.2 Fatty acid profile of oils from roasted *Ugb*a seed oil

Table 2 presents the fatty acid profile of oils obtained from *Ugba* seeds subjected to different roasting temperatures. The results demonstrate that roasting temperature influenced both the number and relative proportions of fatty acids detected in the extracted oils. The unroasted seed oil contained 12 identified fatty acids, whereas 13 fatty acids were detected in oils obtained from seeds roasted at 100, 115 and 145 °C, and 14 fatty acids were identified at 130 °C. This pattern differs from the findings of Ifeoluwa *et al*. (2014), who reported 16 fatty acids in raw *Ugba* seed oil, 17 in cooked seed oil, 4 in oil from 10 kGy-irradiated seeds and 9 in oil from seeds subjected to both irradiation and cooking. Such differences may be associated with genetic or varietal characteristics of the seeds, geographical origin, maturity, pretreatment conditions, roasting regime, extraction procedure and analytical sensitivity.

The saturated fatty acid (SFA) fraction showed a pronounced response to roasting. The unroasted oil recorded the lowest SFA content (14.05%), whereas the oil from seeds roasted at 145 °C recorded the highest value (41.77%), the value at 160 °C was 34.03%. The individual saturated fatty acids, particularly lauric, myristic, palmitic and stearic acids, generally increased as roasting temperature increased. This shift may reflect thermal alteration of the lipid matrix, including changes in the degree of unsaturation and relative concentration of individual fatty acids during heating. The progressive increase in SFA concentration is consistent with the greater thermal stability generally associated with saturated lipids, although the nutritional implications of

increasing long-chain SFAs must also be considered. Antoniassi *et al.* (2013) noted that fatty acid composition is important in determining the nutritional and functional characteristics of edible oils, while Vittori Gouveia *et al.* (2017) reported that lauric and myristic acids can influence LDL-cholesterol, whereas stearic acid has a comparatively smaller effect on LDL-cholesterol.

Lauric acid ranged from 4.17 to 9.64%, while myristic acid increased from 3.11% in the unroasted oil to 8.33% at 160 °C. The stearic acid content ranged from 2.39 to 7.03%. Relative to the Codex values (4.80 to 6.70 %), the stearic acid concentration in the unroasted oil and oils from 100, 115, 130 and 145 °C treatments fell within the reported range, whereas the 160 °C sample (7.03%) exceeded it. Myristic acid concentrations in all samples were also higher than the 0.10% value recommended by Codex (2003). Palmitic acid increased consistently from 3.84% in the unroasted oil to 10.08% at 160 °C. Nevertheless, all observed palmitic acid values remained below the maximum range (7.90 to 12.00%) reported by Codex (2003). The differences between the present results and standards or earlier reports may be attributable to cultivar, growing environment, seed maturity, pretreatment, processing conditions and analytical methodology.

The SFA content of the unroasted oil (14.05%) was higher than the 5.56% reported by Ifeoluwa *et al.* (2014) and the 9.11% reported by Onwuzuruike *et al.* (2024). These discrepancies further demonstrate that fatty acid composition is not fixed and may vary with genetic background, geographical origin, maturity and postharvest or thermal processing conditions. Ogbonna and Ukaan (2013) similarly identified cultivar, origin, pretreatment, harvest period, fruit maturity and pedoclimatic conditions as factors capable of modifying fatty acid composition. In contrast to the SFA fraction, total unsaturated fatty acids (UFAs) decreased as roasting temperature increased. The unroasted oil contained the highest UFA concentration (85.30%), which declined to 58.23% at 145 °C before increasing slightly to 65.87% at 160 °C. Monounsaturated fatty acids (MUFAs) were dominated by oleic acid and ranged from 25.81% in the unroasted oil to 22.81% at 160 °C. Although the oleic acid concentration was substantially higher than the 8.02% reported by Ifeoluwa *et al.* (2014), it was lower than the Codex ranges (35.0 – 69.0 %) (Codex, 1999) and 35.90 to 43 % of the reviewed Codex (2003) standard. Oleic acid is nutritionally relevant because of its association with favourable lipid characteristics, while its relatively high degree of oxidative stability can also contribute to the resistance of oils to oxidation (Kim et al., 2010; Sharma *et al.,* 2023).

Polyunsaturated fatty acids (PUFAs) also declined with increasing roasting temperature, from 59.49% in the unroasted oil to 35.42% at 145 °C, followed by a value of 42.76% at 160 °C. Linoleic acid decreased from 32.90 to 24.34%, while linolenic acid declined from 11.63 to 5.26%. The reduction in PUFA concentration with thermal treatment may be related to the greater susceptibility of multiple carbon-carbon double bonds to thermal oxidation and other degradation reactions. Ukozor and Onyeka (2016) noted that PUFAs contribute substantially to the nutritional quality of oils but can reduce oxidative stability because of their high degree of unsaturation. The linoleic acid concentrations obtained in the present study were lower than the 53.63% reported by Ifeoluwa *et al.* (2014), but remained within the Codex ranges (25.00 to 48.00%). Similarly, the linolenic acid concentrations were lower than the 24.55% reported by Ifeoluwa *et al.* (2014). These differences may again reflect differences in seed material and processing history.

The oil samples also contained eicosatrienoic, arachidonic, docosahexaenoic and tetracosapentaenoic acids in varying proportions. Arachidonic acid decreased from 3.28% in the unroasted oil to 0.72% at 160 °C, while docosahexaenoic acid declined from 1.27 to 0.14%. Tetracosapentaenoic acid, a very-long-chain polyunsaturated fatty acid, declined from 7.28% in the unroasted oil to 3.99% at 160 °C. The presence and progressive reduction of these highly unsaturated fatty acids further indicate the sensitivity of some lipid components to thermal treatment.

The MUFA/PUFA ratio increased from 0.43 in the unroasted oil to 0.64 at 145 °C and 0.54 at 160 °C. In general, a higher MUFA/PUFA ratio is associated with greater oxidative stability because MUFAs are less susceptible to oxidation than PUFAs, although oil stability is also

determined by minor constituents, antioxidant compounds and the positional distribution of fatty acids within triacylglycerols (Akil *et al.,* 2015). The relatively higher MUFA/PUFA ratios observed at the higher roasting temperatures therefore suggest improved resistance to oxidation, but this should be interpreted alongside the accompanying reduction in PUFA concentration and potential nutritional consequences.

The P/S index, representing the ratio of PUFA to SFA, declined progressively from 4.23 in the unroasted oil to 0.85 at 145 °C, before increasing to 1.26 at 160 °C. Although the index remained above the adequacy threshold of 1 (Lawton *et al.,* 2000), its marked reduction with roasting indicates a shift from a highly polyunsaturated lipid profile towards a more saturated profile. From a processing perspective, this shift may favour oxidative stability; however, from a nutritional perspective, retention of nutritionally important unsaturated fatty acids is also desirable. Consequently, the choice of roasting temperature should consider the intended balance between oil stability and preservation of unsaturated fatty acids. According to London (1984), values of 0.45 and below are considered inadequate, since they are related to the higher increase in cholesterol levels. Hence, P/S index of all oil samples may be considered excellent, with high nutritional quality.

3.3 Antioxidant Properties of Oils from Roasted African Oil Bean Seeds

The antioxidant properties of oils obtained from African oil bean seeds roasted at different temperatures are presented in Table 3.

Total Flavonoid Content

Total flavonoid content varied significantly ($p < 0.05$) among the oil samples, ranging from 0.87 to 2.91 CE mg/g. The unroasted oil recorded the lowest value (0.87 CE mg/g), whereas the oil from seeds roasted at 145 °C had the highest value (2.91 CE mg/g). Flavonoid concentration increased progressively from 1.08 CE mg/g at 100 °C to 2.91 CE mg/g at 145 °C, followed by a slight decline to 2.87 CE mg/g at 160 °C. This trend suggests that moderate roasting promoted the release, liberation or apparent concentration of flavonoid compounds in the oil, whereas further heating beyond 145 °C may have initiated partial thermal degradation of some heat-sensitive constituents (Xu *et al.,* 2007).

Flavonoids are plant secondary metabolites with recognized radical-scavenging and antioxidant activities (Xiaohui *et al*., 2017). The higher flavonoid concentrations observed in the roasted samples relative to the unroasted oil therefore indicate that roasting can enhance the measured antioxidant potential of *Ugba* seed oil, particularly when the temperature is controlled. However, the slight decline at 160 °C demonstrates that the beneficial effect of roasting is not necessarily linear and that excessive thermal exposure may diminish some bioactive constituents. Similar temperature-dependent changes in antioxidant-related compounds have been reported in roasted oilseeds, emphasizing the importance of optimizing roasting conditions rather than simply maximizing temperature (Padayatty *et al.*, 2003).

Total Phenolic Content (TPC)

Total phenolic content ranged from 12.06 to 14.44 mg GAE/100 g and differed significantly ($p < 0.05$) among the treatments. The unroasted oil contained the lowest TPC (12.06 mg GAE/100 g), whereas the oil obtained from seeds roasted at 160 °C recorded the highest value (14.44 mg GAE/100 g). Unlike the flavonoid profile, TPC increased consistently with roasting temperature, from 12.50 mg GAE/100 g at 100 °C to 14.44 mg GAE/100 g at 160 °C. This response suggests that thermal treatment enhanced the measurable phenolic fraction of the extracted oil. Heating may facilitate the liberation of phenolic compounds from cellular structures or promote the formation of extractable phenolic derivatives, thereby increasing their apparent concentration (Cory *et al.,* 2018). Phenolic compounds contribute to antioxidant activity through their ability to donate hydrogen atoms or electrons and stabilize reactive species (Siyanbola *et al.,* 2017; Xiaohui *et al.,* 2017). Accordingly, the progressive increase in TPC with roasting indicates that roasting may improve one

component of the antioxidant system of *Ugba* seed oil. Nevertheless, TPC alone should not be used as a complete measure of antioxidant performance because antioxidant activity depends on the identity, concentration and interaction of individual compounds as well as the assay employed (Cory *et al.,* 2018). The increase in TPC at 160 °C, together with the decline in TFC at the same temperature, also demonstrates that different classes of phenolic constituents can respond differently to thermal treatment.

3.4 Antioxidant Activities of Oils from Roasted African Oil Bean Seeds

The antioxidant activities of the oils obtained from African oil bean seeds roasted at different temperatures were assessed using DPPH and FRAP assays, as shown in Table 4.

DPPH (1,1-Diphenyl-2-Picrylhydrazyl)

The DPPH assay measures the capacity of antioxidant compounds to quench the DPPH radical through electron or hydrogen donation (Durmaz and Gökmen, 2019). In the present study, DPPH radical-scavenging activity ranged from 54.75 to 67.90%. The unroasted oil exhibited the lowest activity (54.75%), while the oil from seeds roasted at 145 °C showed the highest value (67.90%). Radical-scavenging activity increased progressively from 57.79% at 100 °C to 67.90% at 145 °C, but declined slightly to 67.22% at 160 °C. The significant difference ($p < 0.05$) among the samples indicates that roasting temperature had a measurable effect on DPPH-scavenging activity.

The progressive increase in DPPH activity up to 145 °C may be associated with the enhanced availability or formation of antioxidant constituents during roasting (Szydłowska-Czerniak and Łaszewska, 2015), as also reflected in the increases in total phenolic and flavonoid contents. The subsequent decline at 160 °C suggests that prolonged or more intense heating may begin to degrade some thermolabile antioxidant compounds. This pattern is consistent with the concept of an optimum roasting temperature at which the release or formation of antioxidant compounds exceeds their thermal degradation (Ramezani *et al.,* 2021). Therefore, within the conditions evaluated in this study, 145 °C appears to provide a favourable roasting temperature for maximizing DPPH radical-scavenging activity.

FRAP (Ferric Reducing Antioxidant Power)

FRAP values ranged from 3.52 to 4.92 µg/ml and differed significantly ($p < 0.05$) among the oil samples. The unroasted oil recorded the lowest FRAP value (3.52 µg/ml), whereas the oil from seeds roasted at 145 °C had the highest value (4.92 µg/ml). FRAP activity increased from 3.85 µg/ml at 100 °C to 4.92 µg/ml at 145 °C, followed by a decline to 4.03 µg/ml at 160 °C. This response closely paralleled the DPPH pattern and further indicates that roasting to 145 °C enhanced the reducing capacity of the oil, while additional heating to 160 °C diminished the response.

The FRAP assay is based on the ability of antioxidant compounds to reduce Fe3+ to Fe2+. The resulting Fe^{2+} forms a coloured complex with TPTZ, and greater absorbance reflects greater reducing capacity (Pan *et al.,* 2020; Benzie and Strain, 1996). An important limitation is that FRAP is particularly suited to hydrophilic reducing compounds and may not fully represent the activity of lipophilic antioxidants present in edible oils (Szydłowska-Czerniak and Łaszewska, 2015). The agreement between the DPPH and FRAP results nevertheless supports the conclusion that roasting at 145 °C produced the strongest antioxidant response under the conditions of this study.

4.0 Conclusion and Recommendations

The effect of roasting African oil bean seeds at different temperatures on the oil yield, fatty acid profile, antioxidant properties and activities were evaluated in the present study. Findings from this study demonstrate that roasting altered the fatty acid composition, antioxidant composition and activities of *Ugba* seed oil. Higher roasting temperatures generally promoted an increase in saturated fatty acids and a reduction in several unsaturated fatty acids, indicating a shift in lipid composition that may improve oxidative resistance but reduce the relative abundance of nutritionally desirable PUFAs. At the same time, roasting enhanced total phenolic content across

the temperature range and increased flavonoid content up to 145 °C. The antioxidant assays further showed that 145 °C gave the highest DPPH and FRAP activities. These findings indicate that the optimum roasting temperature depends on the specific quality attribute being prioritized. If maximum oil yield is the primary objective, the 160 °C treatment identified in the study is advantageous; if antioxidant performance and a more balanced lipid profile are prioritized, roasting at approximately 145 °C appears more appropriate.

References

Adepoju, T. F., Esu1, I. O., Olu-Arotiowa, O. A. and Blessed, E. (2019). Oil extraction from butter fruit (*Dacryodes edulis*) seeds and its optimization via response surface and artificial neural network. *Nigerian Journal of Technological Development*, 16(2): 56-62.

Akil, E., Castelo-Branco, V. N., Costa, A. M. M., do Amaral Vendramini, A. L., Calado, V. and Torres, A. G. (2015). Oxidative stability and changes in chemical composition of extra virgin olive oils after short-term deep-frying of french fries. *Journal of the American Oil Chemists' Society,* 92(3): 409–421.

Akindele, F. A. and Nsuhoridem, I. J. (2018). *Extraction of vegetable oils from agricultural materials: A Review*. *Proceedings of the 12th CIGR Section VI International Symposium*, held at the International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria, 22–25 October, 1185-1206.

Antoniassi, R., Arriel N. H. C., Gonçalves, E. R., Freitas, S. C., Zanotto, D. L. and Bizzo, H. R. (2013). Influence of the culture conditions on the composition of the seeds and the sesame oil. *Rev CeresViçosa*, 60(3):301-310.

AOCS (1995). Official methods and recommended practices of the American Oil Chemists' Society (5th ed.). Champaign, IL: American Oil Chemist's Society 4th ed., AOCS Press, Champaign, Additions and Revisions, Method Cd 18–90.

Arab, R., Casal, S., Pinho, T., Cruz, R., Freidja, M. L. and Lorenzo, J. M. (2022). Effects of seed roasting temperature on sesame oil fatty acid composition, lignan, sterol and tocopherol contents, oxidative stability and antioxidant potential for food applications. *Molecules, 27*(14): 4508.

Benzie, I. F.F and Strain, J. J. (1996). The ferric reducing ability of Plasma (FRAP) as a measure of antioxidant power: The FRAP assay. *Analytical Chemistry,* 239 (1): 70 – 76.

Codex (2003). *Codex Standard for Named Vegetable Oils*: Codex Stan 210 (Amended 2003, 2005), pp. 13.

Codex (1999).Codex Alimentarius Commission. *Codex Standard for Named Vegetable Oils.* Codex Stan 210. Pp 1-16.

[www.codexalimentarius.org/input/download/standards/63/CXS_210e.pdf]. Retrieved 7/10/24

Cory, H., Passarelli, S., Szeto, J., Tamez, M. and Mattei, J. (2018). The role of polyphenols in human health and food systems: A mini-review. *Fronteirs Nutrition*, 5: 87-96.

Durmaz, G. and Gökmen, V. (2019). Effect of refining on bioactive composition and oxidative stability of hazelnut oil. *Food Research International,* 116:586–591

Emelike, N. J. T., Akusu, M. O. and Ujong, A. E. (2017). Antioxidant and physicochemical properties of oils extracted from cashew (*Anacardium occidentale*) kernels. *International Journal of Food Sciences and Nutrition,* 2(6): 122–128

Esther, U. I., Anthony, E. A., Peace, O. and Macdonald, I. (2008). Characteristics and Composition of African Oil Bean Seed (*Pentaclethra macrophylla Benth*). *Journal of Applied Sciences,* 8(7): 1337-1339

Geng, L., Zhou, W., Qu, X., Sa, R., Liang, J. and Wang, X. (2023). Iodine values,

peroxide values and acid values of Bohai algae oil compared with other oils during the cooking. *Heliyon, 9*(4): Article e15088. https://doi.org/10.1016/j.heliyon.2023. e15088

Ghafoor, K., Ahmed, I. A. M., ¨Ozcan, M. M., Al-Juhaimi, F. Y., Babiker, E. E. and Azmi, I. U. (2020). An evaluation of bioactive compounds, fatty acid composition and oil quality of chia (*Salvia hispanica* L.) seed roasted at different temperatures. *Food Chemistry, 333*, Article 127531. https://doi.org/10.1016/j.foodchem.2020.127531

Gilbraith, W. E., Carter, J. C., Adams, K. L., Booksh, K. S. and Ottaway, J. M. (2021). Improving prediction of peroxide value of edible oils using regularized regression models. *Molecules, 26*(23). https://doi.org/10.3390/molecules26237281

Hassan, M. A.M. (2012). Studies on Egyptian sesame seeds (*Sesamum indicum L.*) and its products - physicochemical analysis and phenolic acids of roasted Egyptian sesame seeds (*Sesamum indicum L.*). *World Journal of Dairy Food Science*, 7 (2): 195-201.

Ifeoluwa, O. Victor, N. E., Obadina A. and Kikelomo, O. (2014). Fatty acid profile of gamma-irradiated and cooked African oil bean seed (*Pentaclethra macrophylla Benth*). *Food Science and Nutrition*, 12:1-6. doi: 10.1002/fsn3.176

Pan, F., Wen, B., Luo, X., Wang, C., Wang, X., Guan, X., Xu, Y., Dang, W. and Zhang, M. (2020). Influence of refining processes on the bioactive composition, in vitro antioxidant capacity, and their correlation of perilla seed oil. *Journal of Food Science*, 85(4): 1160–1166. https://doi.org/10.1111/1750-3841.15070

Kim, J., Kim, D. N., Lee, S. H., Yoo, S. H. and Lee, S. (2010). Correlation of fatty acid composition of vegetable oils with rheological behavior and oil uptake. *Food Chemistry,* 118: 398–402.

Kumar, M., Tomar, M., Potkule, J., Verma, R., Punia, S., Mahapatra, A., Belwal, T., Dahuja, A., Joshi, S. and Berwal, M.K. (2021). Advances in the plant protein extraction: Mechanism and recommendations. *Food Hydrocolloids*, 115: 106595

Lawton, C. L., Delargry, H. J., Brockman J., Simith, R. C. and Blundell, J. E. (2000). The degree of saturation of fatty acids of fatty acids influences in post ingestive satiety. *British Journal of Nutrition,* 83 (5): 473 - 482.

London (1984). Department of Health and Social Security. Diet and cardiovascular disease. London: *HMSO*. Pp. 1984-2028.

Ogbonna, P.E. and Ukaan, S. I. (2013). Chemical composition and oil quality of seeds of sesame accessions grown in the Nsukka plains of South Eastern Nigeria. *African Journal of Agricultural Research,* 8 (9): 797–803.

Onwuzuruike, U., Inyang, U. E., Edima-Nyah, P., Abasiekong, S., Iguh, B. and Ihemeje, C. (2024). Characterization of edible oils from different varieties of African oil bean seeds. *Asian Science Bulletin*, 2(4): 361-374. *https://doi.org/10.3923/asb.2024.361.374*

Onyekachi, I. A., Ifeanyichukwu, O. N. V. and Simonyan, K.J. (2021). Postharvest processing, packaging and storage of African oil bean seed. *Poljopr. Teh*., 46: 31–46.

Ordu, J. I. and Yingobo, F. E. (2021). Preliminary investigation of oil from *Pentachlethra microphylla* seeds as new excipient in cosmetic/pharmaceutical cream formulation. *Asian Journal of Science and Technology*, 12(3): 11575-11580.

Osabor, V. N., Okonkwo, P. C. and Ikeuba, A. I. (2017). Chemical profile of leaves and seeds of *Pentaclethra macrophylla* Benth. *Journal of Medicinal Plant and Herbal Therapy Research,* 5(1): 11-17.

Osuagwu, G. G. E and Ihenwosu, A. O. (2014). Phytochemical composition and antimicrobial activity of the leaves of Alchoracordifolia, sanvieraliberica and llvariachamae (P.Beauv). *American Journal of Phytomedicine and Clinical Therapeutics,* 2(1): 001-012.

Padayatty, S., Katz, A., Wang, Y., Eck, P., Kwon, O., Lee, J., Chen, S., Dutta, S. and Levine, M. (2003). Vitamin C as an antioxidant evaluated of its role in disease prevention. *Journal of American College of Nutrition,* 22 (1): 18-35.

Ramezani, M., Hashemi, M., Varidi, M. and Rezaie, M. (2021). Health risk assessment and determination of heavy metals in sesame Oils. *Journal of Nutrition, Fasting and Health*, 9:342–352.

Ruslan, K., Happyniar, S. and Fidrianny, I. (2018). Antioxidant potential of two varieties of *Sesamum indicum* L. collected from Indonesia. *Journal of Taibah University Medical Sciences*, 13(3): 211– 218.

Salama, M.A., Owon, M.A., Osman, M.F., Awatif, I. and Matthäus, B. (2018).

Characterization of Egyptian *Moringa oleifera* Lipids (whole seeds and kernels). *Journal of Food Dairy Science*, **9**(12): 371‑376 (2018)

Salama, M.A., Owon, M.A., Osman, M.F., Awatif, I. and Matthäus, B. (2019). *Moringa oleifera*‑An interesting source of valuable compounds. 17th Euro Fed Lipid congress and Expo. 20‑23 October, Sevilla, Spain. Pp 54-63.

Sharma, K., Kumar, M., Lorenzo, J. M., Guleria, S. and Saxena, S. (2023). Manoeuvring the physicochemical and nutritional properties of vegetable oils through blending. *Journal of the American Oil Chemists' Society*, 100(1): 5–24.

Shingawa, F.B., De Santana, F.C., Araujo, E., Purgatto, E. and Mancini-Filho, J. (2018). Chemical composition of cold pressed Brazilian grape seed oil. *Food Science and Technology*, 38(1):164‑171.

Şimşek, E., Özcan, M.M., Arslan, D., Ünver, A. and Kanbur, G. (2015). Changes in chemical composition of some oils extracted from seeds roasted at different temperatures. *Quality Assurance and Safety of Crops and Foods*, 7 (5): 801-808

Siyanbola, T.O., Akinsola, A.F., Obanla, O.R., Adebisi, A.A., Akinsiku, A.A., Olanrewaju, I.O., Ogunniran, K.O., Taiwo. O.S., Ajanaku, K.O. and Bamgboye, O.A. (2017).Studies on the antibacterial and anticorrosive properties of synthesized hybrid polyurethane composites from castor seed oil. *Rasayan Journal of Chemistry,* 10(3): 1003-1014.

Szydłowska-Czerniak, A. and Łaszewska, A. (2015). Effect of refining process on antioxidant capacity, total phenolics and prooxidants contents in rapeseed oils. *LWT-Food Science and Technology*, 64(2):853–859.

Ukozor, A.U.C. and U.E. Onyeka, 2016. Some quality indices and fatty acid profile of pure-culture fermented Ugba (*Pentaclethra macrophylla* Benth) condiment oil extract. *International Journal of Advance Academic Research, Arts Human Education*, 2: 24-30.

Vittori Gouveia, L. D. A., Lilia, Z.A. and Annie, S. B. M. (2017). Physical-chemical characterization and nutritional quality of sesame oil (*Sesamum indicum L.*). *Journal of Nutrition Health Food Science,* 5(1): 1-7.

Xiaohui, L., Lin, Z., Tong, L., Charles, B., Xiong, F. and Rui, H. L. (2017). Phenolic content, antioxidant and antiproliferative activities of six varieties of white sesame seeds (*Sesamum indicum* L.). *Royal Society of Chemistry Advances*, 7: 5751–5758

Xu, B.J., Yuan, S.H. and Chang, S.K.C. (2007). Comparative studies on the antioxidant activities of nine common legumes against copper-induced human low-density lipoprotein oxidation in vitro. *Botanical Bulletin of Academia Sinica,* 46: 99 – 106