



Stability Indices and Micro-component Assessment of African Oil Bean Seed Oil Blended with Refined Palm Olein

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Abstract:

This study assessed the stability indices and micronutrient composition of African oil bean (*Pentaclethra macrophylla*) seed oil blended with refined palm olein (RPO). Edible oil was extracted from African oil bean seeds and blended with refined palm olein in varying proportions. The blended oils were subjected to stability studies for 12 days using an accelerated method (Schaal's oven test), and the progression of oxidation was evaluated by determining the stability indices and micro-component content of the oil samples. The data generated were analyzed using one-way ANOVA, and mean separation was performed using Duncan's multiple range test at a 95% confidence level. The results revealed significant differences ($p < 0.05$) across all measured parameters among the different oil samples. Oil yield determination showed that African oil bean seeds have a high oil content of 43.21%. The stability indices were affected during storage. The findings indicated that blended oils with a higher proportion of refined palm olein exhibited lower increases in peroxide value, free fatty acid value, and thiobarbituric acid value compared to pure African oil bean seed oil and blends with a higher proportion of African oil bean seed oil. The iodine values (IVs) of the oils decreased during storage, indicating depletion of double bonds. Specifically, AB100 decreased from 118.48 to 87.41 g L/100 g, RPO100 from 88.04 to 78.32 g L/100 g, RPO15:AB85 from 114.16 to 92.74 g L/100 g, RPO30:AB70 from 110.57 to 95.21 g L/100 g, and RPO50:AB50 from 102.20 to 94.14 g L/100 g. Vitamin E and beta-carotene contents decreased with accelerated storage; however, increasing the proportion of refined palm olein improved their retention. In conclusion, blending African oil bean seed oil with refined palm olein enhances its oxidative stability, with the highest stability observed in the 50:50 oil blend.

Keywords: African oil bean seed, micro-component, oxidative stability, refined palm olein.

1. Introduction

Vegetable oils are lipids extracted from plant sources and are widely used in food production, cooking, and frying. Due to their chemical composition, particularly their high content of unsaturated fatty acids, vegetable oils are generally considered healthier alternatives to animal fats. However, many vegetable oils have limited industrial applications in their native form because of their inherent chemical and physical properties (Rani et al., 2023; Tan, 2023). Commonly studied oils such as palm oil, soybean oil, canola oil, and sunflower seed oil dominate both research and commercial use, while indigenous oilseeds remain underexplored (Shahbandeh, 2023).

African oil bean seed (*Pentaclethra macrophylla*), locally known as Ugba, is an underutilized tropical crop widely consumed in southern Nigeria as a traditional food condiment (Obasi et al., 2019; Akinwande et al., 2020). The seeds are rich in proteins, essential amino acids, minerals, vitamins, and bioactive compounds

such as flavonoids, tannins, and saponins. Its oil is particularly notable for its high proportion of unsaturated fatty acids, including oleic and linoleic acids, as well as antioxidant compounds such as tocopherols. These attributes suggest potential health benefits, including improved lipid profiles and reduced risk of cardiovascular diseases, as well as possible anti-inflammatory and anticancer effects (Obasi et al., 2019; Akinwande et al., 2020). Despite these promising characteristics, the oil remains insufficiently studied, particularly in terms of its functional and stability properties.

Palm olein, the liquid fraction obtained from the controlled fractionation of palm oil, is widely used as a frying oil due to its favorable oxidative stability and resistance to thermal degradation (Elburg, 2023; Kyriakopoulou et al., 2021). It contains a balanced composition of unsaturated fatty acids and natural antioxidants such as tocotrienols and carotenoids, contributing to its extended shelf life and stability during high-temperature applications (Basiron and Chan, 2020; Rohman et al., 2021). Its compatibility with other vegetable oils also makes it suitable for blending to enhance functional and nutritional properties (Kurek et al., 2017).

A major challenge associated with edible oils is oxidative rancidity, a degradation process driven primarily by the oxidation of unsaturated fatty acids, leading to the formation of undesirable compounds such as peroxides, aldehydes, and ketones (Al-Farga et al., 2020; Frankel, 2018). This process adversely affects the sensory quality, nutritional value, and safety of oils. Improving oxidative stability is therefore critical for extending shelf life and maintaining quality. Various modification techniques, including hydrogenation, interesterification, fractionation, and blending, have been employed to address this issue (Basiron and Chan, 2020). Among these approaches, oil blending is particularly advantageous as it allows for the optimization of physicochemical properties, nutritional composition, and oxidative stability without altering the natural structure of the oils. While both African oil bean seed oil and palm olein possess desirable characteristics, there is limited information on their combined performance, particularly regarding oxidative stability.

Therefore, this study aims to evaluate the oxidative stability of blends of African oil bean seed oil and palm olein. By addressing this gap, the study seeks to provide insights into the potential of these blends for improved shelf life, enhanced nutritional quality, and broader industrial and culinary applications

2. Material and Method

Material

Fresh seeds of African oil bean seeds (Nsukka variety) were procured from Garki market in Enugu North Local Government Area, Enugu. Refined palm olein was purchased from edible oils segment of shoprite stores, Umuahia Abia State. Processing of African oil bean seeds was carried out at Food Science and Technology Laboratory, Michael Okpara University of Agriculture, Umudike (MOUAAU). Extraction of African oil bean seed oil was done using Soxhlet apparatus and was carried out at the National Root Crop Research Institute. All reagents will be of analytical grade.

Chemicals

The chemicals used included n-hexane, potassium iodide solution, acetic acid–dichloromethane solvent mixture (3:2 v/v), starch solution (1%), 0.01 N sodium thiosulfate solution, diethyl ether–ethanol mixture (1:1 v/v), phenolphthalein indicator, 0.1 N potassium hydroxide solution, 3.86% perchloric acid, carbon tetrachloride, and Wij's solution.

Experimental design

The study employed a completely randomized design (CRD). Five oil samples comprising pure oils and their blends were prepared and analyzed. Oxidative stability was monitored over a 12-day storage period under accelerated conditions, with measurements taken at 3-day intervals (days 0, 3, 6, 9, and 12). All analyses were conducted in triplicate.

Processing of African oil bean seeds into flour

African oil bean seeds were processed into flour following the method of Onwuzuruike et al. (2025) with slight modifications. One kilogram of seeds was cleaned and sorted to remove defective ones. The selected seeds were boiled at 100°C for 20 min, manually cracked, and dehulled using a stainless-steel knife. The cotyledons were washed with potable water and cut into small pieces (approximately 1.5 cm). The samples

were dried in a hot air oven (Model SX3-4.5-15, China) at 60°C for 24 h. The dried samples were milled using an electric blender (Model 2268-94A, Binatone, China) to obtain flour, which was then stored in airtight containers for further use.

Extraction of African oil bean seed oil

Oil extraction was carried out using the Soxhlet method as described by Onwuzuruike et al. (2022) with slight modification. A 100 g portion of the flour was placed in a thimble and extracted with 350 mL of n-hexane in a 500 mL round-bottom flask. The extraction was performed at 69°C for 12 h. After extraction, the solvent was recovered using a rotary evaporator, and the extracted oil was collected, weighed, and stored in amber-colored airtight containers. The extraction was repeated to obtain sufficient oil for analysis.

Oil yield determination

The percentage yield of from the oil seeds was calculated using the equation 1 described by Adepoju et al. (2019).

$$\text{Oil yield (\%)} = \frac{W_o}{W_s} \times 100 \quad (1)$$

Where: W_o = mass of oil extracted (g), W_s = mass of the seed (g).

Formulation of oil blends

Refined palm olein and oil from African oil bean seeds were blended in different proportions as shown in Table 1. The sample codes are also presented in Table 1.

Table 1. Formulation of oil blends (%)

| Sample codes | African oil bean seed oil (AB) | Refined palm olein oil (RPO) |
|--------------|--------------------------------|------------------------------|
| RPO100 | 100 | 0 |
| AB100 | 0 | 100 |
| RPO15:AB85 | 15 | 85 |
| RPO30:AB70 | 30 | 70 |
| RPO50:AB50 | 40 | 60 |

Keys: RPO – Refined Palm Olein, AB - African oil bean seed oil

Oxidative stability studies

Oxidative stability was evaluated using the the Schaal oven test as described by Djikeng et al. (2018). Oil samples were stored in an oven at 70°C for 12 days. Samples were withdrawn at 3-day intervals (days 0, 3, 6, 9, and 12) for analysis.

Determination of stability indices

Peroxide value was determined according to the AOCS (1993c) method. Free fatty acids were determined according to AOCS (1993d) method. The thiobarbituric acid number was determined as described by AOAC (1999) while iodine value was determined according to the AOCS (1993b) method.

Determination of vitamin E content

The method described by Dauqan (2011) will be used to determine the vitamin E. About 1 gram of the oil sample was accurately weighed using an analytical balance. This sample was then dissolved in 10 mL of hexane or ethanol in a volumetric flask. The solution was mixed thoroughly to ensure complete dissolution of the oil. Following this, the mixture was subjected to centrifugation to separate any solid impurities. The clear supernatant was carefully transferred to a clean container. If hexane was used, the solvent was evaporated using a rotary evaporator at a controlled temperature, leaving behind the extracted vitamin E in a concentrated form. After the extraction, the remaining residue was re-dissolved in a known volume of mobile phase solvent suitable for HPLC, usually a mixture of hexane and isopropanol. The solution was filtered through a 0.45-micron filter to remove any particulate matter before being placed in an HPLC vial. Next, the HPLC system

was calibrated using a standard solution of alpha-tocopherol. The flow rate and temperature of the column were set according to the method specifications. The sample was then injected into the HPLC system, and the retention time for vitamin E was recorded. The UV detector was set to an appropriate wavelength, often around 292 nm, to detect vitamin E. The peaks corresponding to alpha-tocopherol were analyzed, and the area under the curve was calculated. The concentration of vitamin E in the oil samples was determined by comparing the sample peaks to those of the standard solutions, using a calibration curve.

Determination of the beta carotene content

The method described by Dauqan (2011) will be used to determine the beta carotene. The determination of beta-carotene followed a similar extraction process but required a different approach for quantification. Five (5) grams of the oil samples were weighed accurately using an analytical balance. This sample was then dissolved in 20 mL of hexane, which is an effective solvent for extracting beta-carotene. The mixture was shaken vigorously and then allowed to stand for a few minutes to facilitate the separation of phases. After settling, the hexane layer was carefully pipetted off into a clean volumetric flask, ensuring that no water or solid residue was included. Once the extract was prepared, the absorbance of the beta-carotene solution was measured using a spectrophotometer at a wavelength of 450 nm, where beta-carotene has a maximum absorption. To calculate the beta-carotene content, the following formula was applied (eq. 2).

$$\text{Beta - Caroten} = \frac{A_{450} \times D \times V}{\epsilon \times L} \quad (2)$$

Statistical analysis

The experimental data were expressed as mean \pm SD (standard deviation). The data were subjected to one-way analysis of variance (ANOVA) while the Duncan Multiple Range Test (DMRT) method was used to compare the means of experimental data at 95% confidence interval. All statistical analyzes were done using the Statistical Product of Service Solution version 20.0 software.

3. Results and Discussion

Oil yield of African oil bean seeds

The oil yield of African oil bean seed was presented in Table 2. The percentage oil yield of African oil bean seeds was 43.21% which classifies the oil seed as a viable source of vegetable oil. The oil content obtained from this study was below the oil content reported by Esther et al. (2008) (47.90%), while Ordu and Yingobo (2021) and Osabor et al. (2017) reported lower oil yield of 38.09% and 25.54%. respectively. Oil seeds with oil content above 25% are considered to be good sources of edible oils (Akindede and Nsuhoridem, 2018). The oil yields of the present study exceeded 25% and may therefore be classified as good sources of edible oils for possible commercial exploitation.

Table 2. Percentage oil yield of African oil bean seed oil.

| Sample | Percentage oil yield (%) |
|---------------------------|--------------------------|
| African oil bean seed oil | 43.21 \pm 0.07 |

Values are means + standard deviation of duplicate determination

Changes in the peroxide value (PV) of African oil bean seed oil and refined palm olein oil blends

Table 3 presents the changes in peroxide value (PV) of African oil bean seed oil (AB), refined palm olein (RPO), and their blends over a 12-day storage period. PV increased in all samples, indicating progressive lipid oxidation. RPO100 increased from 5.91 to 9.42 meq O₂/kg, AB100 from 1.52 to 13.14 meq O₂/kg, RPO15AB85 from 6.20 to 12.36 meq O₂/kg, RPO30AB70 from 7.46 to 9.41 meq O₂/kg, and RPO50AB50 from 8.16 to 9.42 meq O₂/kg. These changes were significantly different ($p < 0.05$) among the samples.

The results indicate that although AB100 had the lowest initial PV, it exhibited the highest rate of oxidation during storage, exceeding the Codex limit by day 9. In contrast, RPO100 maintained relatively stable PV values throughout the study, remaining within acceptable limits. The higher initial PV observed in RPO100 may be attributed to prior storage conditions before purchase, while the rapid increase in AB100 suggests

greater oxidative susceptibility. Blending improved oxidative stability, as samples with higher proportions of refined palm olein (RPO30AB70 and RPO50AB50) showed slower PV development compared to those with higher African oil bean seed oil content. This trend highlights the stabilizing role of palm olein in the blends. Oils rich in polyunsaturated fatty acids, such as African oil bean seed oil, are more prone to oxidation, whereas palm olein, with a higher proportion of monounsaturated and saturated fatty acids, exhibits greater resistance to oxidative deterioration. Similar observations have been reported by Bordon et al. (2019) and Chen and Liu (2020).

Peroxide value reflects the formation of primary oxidation products (hydroperoxides), and its increase is associated with deterioration in oil quality (Shahidi and Zhong, 2020). According to Codex Alimentarius (2011), the acceptable limit for PV in edible oils is 10 meq O₂/kg. In this study, all samples were within this limit up to day 6, but AB100 and RPO15AB85 exceeded the threshold at later stages, indicating reduced stability in blends with higher African oil bean oil content. Overall, the findings demonstrate that increasing the proportion of refined palm olein enhances oxidative stability, while higher levels of African oil bean seed oil accelerate peroxide formation. This suggests that optimal blending ratios are critical for balancing nutritional benefits and storage stability, reinforcing the potential of palm olein as a stabilizing component in edible oil formulations (Dhyani et al., 2022).

Table 3. Changes in the peroxide value (PV) of African oil bean seed oil and refined palm olein oil blends

| Sample | Storage period (days) | | | | |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| RPO100 | 5.91 ^d ± 1.52 | 6.37 ^c ± 0.52 | 7.07 ^d ±0.00 | 7.29 ^d ±0.80 | 7.42 ^d ±0.00 |
| AB100 | 1.52 ^c ± 1.69 | 4.02 ^d ± 0.69 | 8.96 ^c ±0.03 | 11.58 ^a ±1.52 | 13.14 ^a ±0.03 |
| RPO15:AB85 | 6.20 ^c ±1.36 | 8.51 ^{ab} ±0.36 | 9.97 ^a ±0.13 | 10.97 ^b ±2.29 | 12.36 ^b ±0.13 |
| RPO30:AB70 | 7.46 ^b ±1.46 | 7.49 ^b ±0.46 | 8.30 ^{bc} ±0.05 | 9.03 ^c ±0.05 | 9.41 ^c ±0.05 |
| RPO50:AB50 | 8.16 ^a ±0.71 | 8.58 ^a ±0.61 | 8.91 ^b ±0.10 | 9.14 ^c ±1.37 | 9.42 ^c ±0.10 |

Mean values are mean ± standard deviation of duplicate determination. Mean value in the same column with different superscripts are significantly different (P<0.05). Key RPO – Refined palm olein oil, AB-African oil bean seed. AB100= African oil bean seed 100. RPO 100= Refined palm olein oil 100. RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85. RPO30:AB70= Refined palm olein oil 30, AB-African oil bean seed 70. RPO50:AB50= Refined palm olein oil 50, AB-African oil bean seed 50

Changes in the free fatty acids (FFA) of African oil bean seed oil and refined palm olein oil blends

Changes in free fatty acid (FFA) content of blends of African oil bean seed oil (AB) and refined palm olein (RPO) over 12 days of storage are presented in Table 4. FFA is a key indicator of oil quality, reflecting triglyceride hydrolysis, which can lead to rancidity and off-flavors (El Idrissi et al., 2023). Significant differences (p<0.05) were observed among the samples. RPO100 increased from 1.06 to 2.75%, AB100 from 0.45 to 5.05%, RPO15:AB85 from 1.28 to 4.36%, RPO30:AB70 from 1.97 to 3.63%, and RPO50:AB50 from 2.10 to 2.86%. The higher FFA accumulation in African oil bean oil-rich samples indicates greater susceptibility to lipolytic degradation compared to RPO. This is likely due to African oil bean seed oil's higher polyunsaturated fatty acid content, which is more prone to hydrolysis. In contrast, the lower FFA formation in 100% RPO reflects its higher oxidative and hydrolytic stability, associated with lower unsaturation and refinement. These trends are consistent with previous studies. Elouafy et al. (2022) reported that oils with higher unsaturation show faster FFA development during storage. Similarly, Espinola et al. (2021) observed that refined palm olein exhibits lower initial and progressive FFA values compared to blends with polyunsaturated oils, aligning with the low FFA observed in RPO100 in this study. According to Codex Alimentarius (2011), acceptable FFA limits are below 0.5% for refined oils and 5% for crude oils. All samples met the CODEX standards after 12 days except AB100, which exceeded the refined oil limit, confirming its greater susceptibility to lipolytic degradation. Overall, blending RPO with AB mitigates FFA accumulation, improving storage stability while retaining some of AB's nutritional benefits.

Table 4. Changes in the free fatty acid (FFA) of African oil bean seed oil and refined palm olein oil blends

| Sample | Storage period (days) | | | | |
|------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| RPO100 | 1.06 ^d ±1.07 | 1.56 ^a ±0.67 | 2.05 ^e ±0.02 | 2.43 ^a ±1.56 | 2.75 ^d ±0.02 |
| AB100 | 0.45 ^a ±1.49 | 1.69 ^b ±0.49 | 2.84 ^d ±0.04 | 4.14 ^d ±0.47 | 5.05 ^c ±0.04 |
| RPO15:AB85 | 1.28 ^b ±1.46 | 1.42 ^c ±0.46 | 2.70 ^b ±0.10 | 3.91 ^c ±1.44 | 4.36 ^a ±0.10 |
| RPO30:AB70 | 1.97 ^c ±1.19 | 1.97 ^c ±0.49 | 2.16 ^c ±0.05 | 2.27 ^b ±1.50 | 3.63 ^b ±0.05 |
| RPO50:AB50 | 2.10 ^c ±1.05 | 2.21 ^b ±0.55 | 2.29 ^a ±0.10 | 2.45 ^e ±0.42 | 2.86 ^a ±0.10 |

Mean values are mean ± standard deviation of duplicate determination. Mean value in the same column with different superscripts are significantly different (P<0.05). Key RPO – Refined palm olein oil, AB-African oil bean seed. AB100= African oil bean seed 100. RPO 100= Refined palm olein oil 100. RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85. RPO30:AB70= Refined palm olein oil 30, AB-African oil bean seed 70. RPO50:AB50= Refined palm olein oil 50, AB-African oil bean seed 50

Changes in the iodine value (IV) of African oil bean seed oil and refined palm olein oil blends

Iodine value of African oil bean seed oil, refined palm olein and blends of African oil bean seed oil and refined palm olein are presented in Table 5. The iodine value (IV) of an oil is an index used to assess its level of unsaturation and susceptibility to rancidity (Onwuzuruike et al., 2025). There was significant (p<0.05) difference among the values. A decreasing trend in iodine values was generally observed in all samples over the storage period, indicating progressive reduction in unsaturation levels due to oxidative processes that break down double bonds in the fatty acids. AB100 had the highest iodine value while RPO100 had the lowest value throughout the storage period (Fadda et al., 2022). The IVs of the oils decreased with storage indicating depletion of double bonds. AB100 decreased from 118.48 to 87.41 g I₂/100 g, RPO100 decreased from 88.04 to 78.32 g I₂/100 g, RPO15:AB85 decreased from 114.16 to 92.74 g I₂/100 g, RPO30:AB70 decreased from 110.57 to 95.21 g I₂/100 g, RPO50:AB50 decreased from 102.20 to 94.14 g I₂/100 g respectively.

Table 5. Changes in the iodine value (IV) (g I₂/100 g) of African oil bean seed oil and refined palm olein oil blends

| Samples | Storage period (days) | | | | |
|------------|---------------------------|---------------------------|---------------------------|---------------------------|--------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| AB100 | 118.48 ^a ±0.01 | 112.41 ^a ±0.06 | 107.32 ^a ±0.03 | 101.11 ^b ±0.01 | 87.41 ^d ±0.01 |
| RPO100 | 88.04 ^g ±0.04 | 84.91 ^g ±0.04 | 81.66 ^f ±0.01 | 79.17 ^d ±0.03 | 78.32 ^e ±0.04 |
| RPO15:AB85 | 114.16 ^d ±0.05 | 112.44 ^c ±0.15 | 106.1 ^e ±0.15 | 103.25 ^b ±1.79 | 92.74 ^e ±0.15 |
| RPO30:AB70 | 110.57 ^a ±1.19 | 106.57 ^a ±1.19 | 101.46 ^a ±1.19 | 97.16 ^c ±1.61 | 95.21 ^b ±1.19 |
| RPO50:AB50 | 102.20 ^c ±0.81 | 99.63 ^b ±0.81 | 98.27 ^b ±0.81 | 96.21 ^d ±1.46 | 94.14 ^c ±0.81 |

Mean values are mean ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (P<0.05); Keys: RPO – Refined palm olein oil, AB-African bean seed oil; AB 100= African oil bean seed 100; RPO 100= Refined palm olein oil 100; RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85; RPO30:AB70= Refined palm olein oil 30, AB-African oil bean seed 70; RPO50:AB50= Refined palm olein oil 50, AB-African oil bean seed 50

The iodine value (IV) is typically measured in grams of iodine absorbed per 100 grams of oil, quantifying the level of unsaturation in the oil. Higher IVs suggest greater amounts of unsaturated fatty acids, which may impact oil stability, nutritional profile, and susceptibility to rancidity. Hashempour-Baltork et al. (2018) found that the iodine value of unsaturated oils tends to decrease during storage due to oxidative

degradation. This observation was consistent with the findings of this study where samples with higher initial IV, especially those with more African oil bean seed oil content, experienced greater reductions over the storage period while blended oils with higher refined palm olein proportion had higher iodine value at the end of the storage period. Consequently, blending African oil bean seed oil with refined palm olein significantly improved the stability of African oil bean seed oil.

Changes in the thiobarbituric acid (TBA) of African oil bean seed oil and refined palm olein oil blends

Thiobarbituric acid value of the oil samples are presented in Table 6. There was significant ($p < 0.05$) in the values obtained. Pure African oil bean seed oil (AB100) had the highest TBA throughout the study period while 100% refined palm olein (RPO100) had the lowest TBA values. Consequently, blending both oils resulted in lower TBA values in the blended oils throughout the storage period. Decreasing TBA values could be linked to the reduction in the amount of oxidation-enhancing micro components and impurities capable of sporulating the oxidation process (Idrissi et al., 2022). Furthermore, high TBA in blends containing a high proportion of African oil bean seed oil suggests a more pronounced and possible occurrence of secondary oxidation and the presence of its subsequent products such as aldehydes and ketones compared to other oil samples. However, the TBA values increased steadily after each day of storage. AB100, RPO100, AB50:RPO50 AB70:RPO30 and AB85:RPO15 increased from 0.59 to 1.31 mg/g, 0.68 to 4.51 mg/g, 0.62 to 1.76 mg/g, 0.69 to 2.04 mg/g and 0.74 to 3.09 mg/g respectively. The secondary stage of oxidation occurs when the hydroperoxides decompose to form carbonyls and other compounds, particularly aldehydes. This gives the oil a rancid smell and they are measured by thiobarbituric acid (TBA), being a quality marker for evaluating the quality of oils and fats (Kiralan et al., 2017). Thiobarbituric acid assay is the most widely used method for the measurement of secondary oxidation products, which may contribute to off-flavor of oxidized oils (Lakhlifi et al., 2024). The observed trend of increasing TBA values aligns with findings from other studies, which also reported a progressive increase in TBA values over storage periods for unsaturated oils (Motamedzadegan et al., 2020).

Table 6. Changes in the thiobarbituric acid (TBA) (mg/g) of African oil bean seed oil and refined palm olein oil blends

| Samples | Storage period (days) | | | | |
|------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| RPO100 | 0.59 ^c ±0.71 | 0.87 ^a ±0.71 | 1.06 ^a ±0.53 | 1.21 ^a ±1.91 | 1.31 ^a ±0.53 |
| AB100 | 0.68 ^b ±1.19 | 0.96 ^c ±0.19 | 2.16 ^c ±0.36 | 3.31 ^c ±1.54 | 4.51 ^c ±0.36 |
| RPO50:AB50 | 0.62 ^a ±1.42 | 0.71 ^c ±0.42 | 1.04 ^c ±0.42 | 1.41 ^b ±1.77 | 1.76 ^c ±0.42 |
| RPO30:AB70 | 0.69 ^d ±1.07 | 0.76 ^b ±0.47 | 1.21 ^b ±0.47 | 1.82 ^c ±0.88 | 2.04 ^b ±0.47 |
| RPO15:AB85 | 0.74 ^c ±1.17 | 0.81 ^d ±0.37 | 1.30 ^d ±0.37 | 2.96 ^d ±1.46 | 3.09 ^d ±0.37 |

Mean values are mean ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different ($P < 0.05$); Keys: RPO – Refined palm olein oil, AB-African bean seed oil; AB 100= African oil bean seed 100; RPO 100= Refined palm olein oil 100; RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85; RPO30:AB70= Refined palm olein oil 30, AB-African oil bean seed 70; RPO50:AB50= Refined palm olein oil 50, AB-African oil bean seed 50

Changes in the vitamin E content of African oil bean seed oil and refined palm olein oil blends

Table 7 shows the changes in vitamin E content of African oil bean seed oil (AB) and refined palm olein oil (RPO) blends over a 12-day storage period. There was significant ($p < 0.05$) difference among the values. A decreasing trend in vitamin E was generally observed in all samples over the storage period, indicating progressive reduction in stability due to oxidative processes that break down double bonds. AB100 had the highest vitamin E content while RPO100 had the lowest value throughout the storage period. AB100 decreased from 18.63 to 9.81 mg/100 g, RPO100 decreased from 10.21 to 7.57 mg/100 g, RPO15:AB85 decreased from 17.42 to 9.50 mg/100 g, RPO30:AB70 decreased from 16.81 to 11.79 mg/100 g, RPO50:AB50 decreased from 14.32 to 11.09 mg/100 g respectively. Vitamin E, also known as tocopherol, is an antioxidant vitamin. It is sensitive to degradation upon exposure to light, heat, and oxygen during storage, and its decrease over time

signals reduced antioxidant protection within the oil (Ndomou et al., 2023). This trend indicates a gradual loss of antioxidant capacity in the oils over time, reflecting typical oxidative degradation. Blends with a higher proportion of refined palm olein oil tend to retain higher levels of vitamin E longer compared to those with higher African oil bean seed oil proportions, which may be due to the higher propensity of African oil bean seed oil to undergo oxidation as a result of their level of unsaturation (Pan et al., 2020). More so, the retention of higher vitamin E content in blended oils with higher refined palm olein may be due to the presence of higher saturation levels as well as the presence of tocopherol and tocotrienols which provide better stability against oxidative conditions (Pattnaik and Mishra, 2022).

The declining trend in vitamin E observed in this study aligns with findings by Romani et al. (2021) and Ndomou et al. (2023), who reported that oils tocopherol content degrades during storage. Additionally, previous studies have shown that oils rich in unsaturated fatty acids have reduced oxidative stability (Shahid et al., 2024). The findings of the current study show that the addition of refined palm olein can improve the stability of African oil bean seed oil as well as vitamin E retention during storage.

Table 7. Changes in the vitamin E (mg/100 g) of African oil bean seed oil and refined palm olein oil blends

| Samples | Storage period (days) | | | | |
|------------|--------------------------|---------------------------|---------------------------|--------------------------|--------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| AB100 | 18.63 ^a ±1.10 | 15.92 ^b ± 0.62 | 13.75 ^d ±0.09 | 10.53 ^a ±1.41 | 9.81 ^d ±0.09 |
| RPO100 | 10.21 ^d ±0.90 | 9.74 ^d ± 0.60 | 9.34 ^e ±0.04 | 8.23 ^c 1.11 | 7.57 ^e ±0.04 |
| RPO15:AB85 | 17.42 ^c ±1.00 | 13.73 ^c ±0.62 | 11.12 ^a ± 0.62 | 9.31 ^b ± 1.15 | 9.50 ^a ± 0.62 |
| RPO30:AB70 | 16.81 ^b ±1.07 | 15.83 ^c ±0.53 | 13.62 ^c ±0.15 | 12.10 ^d 0.52 | 11.79 ^c ±0.15 |
| RPO50:AB50 | 14.32 ^e ±0.71 | 13.23 ^a ±0.71 | 13.14 ^b ±0.16 | 12.11 ^c ±0.47 | 11.09 ^b ±0.16 |

Mean values are mean ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (P<0.05); Keys: RPO – Refined palm olein oil, AB-African bean seed oil; AB 100= African oil bean seed 100; RPO 100= Refined palm olein oil 100; RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85; RPO30:AB70= Refined palm olein.

Changes in the beta-carotene content of African oil bean seed oil and refined palm olein oil blends

Table 8 shows the changes in beta-carotene levels of African oil bean seed oil (AB) and refined palm olein oil (RPO) blends over a 12-day storage period. There was significant (p<0.05) difference among the values. RPO100 had the highest beta-carotene content while AB100 had the lowest value throughout the storage period. AB100 decreased from 1.59 to 0.96 mg/100 g, RPO100 decreased from 3.59 to 2.08 mg/100 g, RPO15:AB85 decreased from 1.73 to 1.02 mg/100 g, RPO30:AB70 decreased from 2.41 to 1.86 mg/100 g, RPO50:AB50 decreased from 2.81 to 2.08 mg/100 g respectively. Beta-carotene is a carotenoid that provides antioxidant protection to oils. Its levels often decrease during storage due to factors such as light, heat, and oxygen exposure, which lead to oxidation. A decreasing trend in beta-carotene was generally observed in all samples over the storage period, indicating progressive reduction in stability due to oxidative processes (Sharma et al., 2023). At day 0, the highest beta-carotene content was observed in the RPO100 sample (3.59 mg/100 g), reflecting its high carotenoid composition. The lowest value was recorded in the AB100 sample (1.59 mg/100 g). By day 12, AB100 showed the lowest concentration of beta-carotene content (0.96 mg/100 g), while the RPO50:AB50 blend retained the highest beta-carotene concentration (2.08 mg/100 g), demonstrating the stabilizing effect of refined palm olein oil. A clear trend of decreasing beta-carotene levels, observed across all samples over the storage period, aligns with findings from other studies, such as those by Romani et al. (2021) and Sharma et al. (2023), who reported decreasing beta-carotene content during storage. Also the findings from this study support the reports by Ndomou et al. (2023), who noted that oils with mixed fatty acid profiles, such as those in blended oils, have improved beta-carotene stability. Similarly, Torri et al. (2019) reported that combining oils with different compositions, such as African oil bean seed oil and refined palm olein in this study, can slow down the rate of beta-carotene degradation, possibly due to the interaction of different antioxidants in the blend.

Table 8. Changes in the beta-carotene (mg/100 g) of African oil bean seed oil and refined palm olein oil blends

| Samples | Storage period (days) | | | | |
|------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 0 day | 3 days | 6 days | 9 days | 12 days |
| AB100 | 1.59 ^e ±1.05 | 1.40 ^b ±0.43 | 1.16 ^b ±0.43 | 1.07 ^b ±1.22 | 0.96 ^b ±0.43 |
| RPO100 | 3.59 ^b ±1.32 | 3.26 ^a ±0.45 | 2.90 ^e ±0.04 | 2.88 ^a ±1.44 | 2.08 ^e ±0.04 |
| RPO15:AB85 | 1.73 ^a ±1.44 | 1.46 ^c ±0.43 | 1.25 ^d ±0.19 | 1.12 ^c ±1.11 | 1.02 ^d ±0.19 |
| RPO30:AB70 | 2.41 ^c ±1.29 | 2.31 ^d ±0.38 | 2.16 ^c ±0.38 | 2.05 ^d ±0.68 | 1.86 ^c ±0.38 |
| RPO50:AB50 | 2.81 ^d ±1.19 | 2.61 ^e ±0.36 | 2.27 ^a ±0.53 | 2.12 ^c ±0.53 | 2.08 ^a ±0.53 |

Mean values are mean ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (P<0.05); Keys: RPO – Refined palm olein oil, AB-African bean seed oil; AB 100= African oil bean seed 100; RPO 100= Refined palm olein oil 100; RPO15:AB85= Refined palm olein oil 15, AB-African oil bean seed 85; RPO30:AB70= Refined palm olein oil 30, AB-African oil bean seed 70; RPO50:AB50= Refined palm olein oil 50, AB-African oil bean seed 50.

4. Conclusion

This study demonstrated the oxidative stability of African oil bean seed oil (AB) and its blends with refined palm olein (RPO) under accelerated storage conditions. While African oil bean seed oil is a rich source of edible oil, it is highly prone to oxidation, limiting its standalone suitability for certain food applications. Blending AB with RPO significantly enhanced its stability, with the 50:50 blend showing the highest resistance to oxidative degradation. The findings indicate that, although pure African oil bean seed oil is highly unsaturated, it lacks the thermal and oxidative resilience of refined palm olein. However, when blended with oils of greater stability, such as RPO, African oil bean seed oil shows strong potential as a functional food ingredient, combining nutritional benefits with improved storage and cooking performance.

Authors contribution

Onwuzuruike, U. A. designed the project, procured and processed the raw materials, engaged in analytical procedures and co-wrote the draft manuscript. Uluocha, M. D. extracted the oil samples and formulated the oil blends. Agwo, O. E. conducted the statistical analysis and co-wrote the draft manuscript. Edima-Nyah, A. P. and Okwunodulu, I. N. supervised the project while Obasi, C. B. proofread and corrected the final manuscript. All authors participated actively in the laboratory analysis of this research.

Declaration of conflict of interest

The authors have declared no conflict of interest

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