

Processing Effect on the Physicochemical and Volatile Fatty Acid Profile of African Breadfruit (*Treculia africana*) Seed Oil

Titus U. Nwabueze*, Amarachi G. Emenonye

Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria
Email: *Teeubueze@yahoo.co.uk, Greacy4real@yahoo.com

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Abstract

African breadfruit seeds were subjected to three processing methods—parboiling, cooking and toasting, and the raw was used as control. The purpose of this research was to extract the oil from the seed and to determine the effect of processing on the oil for physicochemical properties and volatile fatty acid profile. Physicochemical properties showed that the colour of the oil varied from golden yellow to brownish yellow with specific gravity varying between 0.802 g/cm³ and 0.813 g/cm³. Percentage yield of oil was 6.14% for raw extract, 6.62% for parboiled extract, 7.56% for toasted extract, and 5.01% for cooked extract. Acid, peroxide and saponification value for oil extracted from the raw seed varied with the processed samples value. The Volatile Fatty Acid (VFA), also known as Short Chain Fatty Acid (SCFA) found inherent in varying concentration, were formic, acetic, propionic, isobutyric, butyric, isovaleric, valeric, isocarproic, hexanoic and heptanoic acid. Overall results prove that heat results in increases in the VFA concentration of the processed oil.

Keywords

Component, Formatting, Style, Styling, African Breadfruit, Volatile Fatty Acid (VFA), Short Chain Fatty Acid (SCFA), Physicochemical

1. Introduction

African breadfruit (*Treculia africana*) constitutes a very important reserve of essential food nutrients that are available at certain critical periods of the year when reliable sources of these nutrients are under cultivation and

*Corresponding author.

are very scarce [1]. African breadfruit is from the Mulberry family—Moraceae and it is a native to many tropical countries like the West Indies, Ghana, Sierra Leone, Nigeria and Jamaica [2]. In recent times African breadfruit has become a delicacy and a specialized meal not only for the rich and urban dwellers in Nigeria but has also become a foreign exchange earner whereby dehulled kernels are sun-dried and exported to cater for the African consumers' interest overseas [1].

The characteristics of oils from different sources depend mainly on their compositions; no oil from a single source can be suitable for all purposes thus the study of their constituents is important.

Of all the major food processing treatment in current use, heat processing is the most encountered and it has a very important effect on various food components and qualities. Depending on such factors as time, temperature, moisture content, presence or absence of reducing or oxidizing agents and other ingredients such as acid, salt, sugars, fat, etc., heat treatment may have either beneficial or detrimental effects. Thus heat treatment must be carefully controlled to avoid or minimize damage to nutritive value, functionality and sensory properties which determine acceptability [3].

Fatty acid is a carboxylic acid with a long aliphatic chain, which is either saturated or unsaturated [4]. They are usually derived from triglycerides or phospholipids, and when they are not attached to other molecules, they are known as “free” fatty acids.

Volatile Fatty Acids (VFAs), also known as Short Chain fatty acids (SCFAs), are fatty acids with aliphatic tail of less than six carbon atoms [5]. Volatile fatty acids are important sources of fuel, because when metabolized, they yield large quantities of ATP due to their ability of being absorbed directly into the blood stream through the intestine capillaries and travel through the portal vein as other nutrients are absorbed [6]. They are metabolized by breaking down to CO₂ and water by the intra-cellular mitochondria, releasing large amounts of energy, captured in the form of ATP through beta-oxidation and the citric cycle [7]. VFAs have been reported to have antimicrobial properties [8]. That is to say, they protect us from viruses, yeasts and pathogenic bacteria in the gut. They do not need to be acted on by bile salts, and VFAs regulate the balance between fatty acid synthesis, fatty acid oxidation, and lipolysis in the body. Fatty acid oxidation is activated by VFAs, while *de novo* synthesis and lipolysis are inhibited. The net result is a reduction of the concentrations of free fatty acids in plasma [8] and a decrease in body weight [8]-[13], thus they are less likely to cause weight gain. They also contribute to the health of the immune system.

Various research works have been done on the physicochemical properties of African breadfruit seed oil [14] and Fatty acids profiles [15]. The aim of the study is to ascertain the Volatile Fatty Acids (VFAs) profile of the African breadfruit (as the fruit is locally available and generally accepted) and the effect heat has on them in order to enhance their nutritional and economic significance.

2. Materials and Methods

Mature African breadfruit seeds were purchased in Umuahia, Abia state. The seeds were authenticated at the Agronomy Department of the National Root Crop Research Institute (NRCRI), Umudike. The seeds were washed and sorted manually to remove bad ones and extraneous materials.

The African breadfruit seeds were divided into four equal parts and subjected to different heat treatments as stated by Fasisi [16] with slight modifications.

One part was parboiled for 10 minutes at 100°C to aid dehulling, thus the parboiled sample. One part was parboiled for 10 minutes, dehulled and then cooked in tap water at 100°C, until soft and tender. This served as the cooked sample. One part was toasted at 180°C, thus the toasted sample. One part was dehulled manually without any heat treatment. This gives the raw sample

The 4 samples were sun dried to constant weight. The samples were ground to fine powder with the laboratory mill and sieved with a 2.5 mm mesh sieve. The flour was preserved in air tight bags at room temperature from which fractions were collected for different analysis [1] [17].

2.1. Extraction of Oil from Seed

The African breadfruit flour samples were placed in the porous cellulose thimble of the soxhlet apparatus. The thimble was placed in an extraction chamber which was suspended above a flask containing the solvent and below a condenser. Heat was applied to the flask and the solvent evaporates and moves to the condenser where it was converted into liquid that trickles into the extraction chamber containing the sample. The extraction cham-

ber is made in such a way that when the solvent surrounding the sample exceeds a certain level it overflows and trickles back down into the boiling flask. The flask containing solvent and lipid was removed at the end of the extraction process. The solvent in the flask was evaporated in a water bath, The oil was then transferred to a desiccator and allowed to cool before being weighed. The drying, cooling and weighing was repeated until a constant dry weight was obtained. The extracted oil sample was sealed in dark brown coloured glass bottle and kept for analytical tests.

2.2. Determination of Physicochemical Properties of Oil

The physical characteristics of African breadfruit seed oil determined included yield, colour (photometric system), specific gravity, were determined by the standard methods as described by [18]. Specific gravity was determined by use of specific gravity bottles at a temperature of $28^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Photometric colour index (pci) of African breadfruit seed oil was determined on 1g sample according to the method described by [19]. The sample was weighed and dissolved in 20 ml water/ethanol mixture. The mixture was filtered after standing for 30 min. The absorbance of the filtrate was measured at 400, 550, 620 and 670 nm using spectrophotometer (Unican He _105Y, England). The solvent was used as blank. Photometric colour index was calculated as

$$pci = 1.29(A400) + 69.70(A500) + 41.20(A620) - 56.41(A670)$$

where A = absorbance.

The acid, saponification, and peroxide values were determined using the procedures described by [20]. The moisture content was determined by the procedure specified by [21]. The density was determined by dividing the weight of the oil by its volume [18].

2.3. Volatile Fatty Acid Composition and Analysis

A 100 mg oil sample was saponified with 1.2 ml of 0.5 M methanolic KOH at 60°C for 10 mins, neutralized with 0.7 M HCl and methylated with 3.0 ml $\text{BF}_3\text{-CH}_3\text{OH}$ for about 10 minutes in a water bath at 60°C . The product was then extracted with petroleum ether ($40^{\circ}\text{C} - 60^{\circ}\text{C}$). The fatty acid methyl ester (FAME) was separated by a GCMS-QP2010 PLUS SHIMADZU, JAPAN. The FAME was injected and separation was on an HP capillary column. The carrier gas was helium at pressure of 116.9kPa. The column oven temperature of 70°C , flow rate 1.80 ml/min with split ratio of 20:0 was employed. The volatile fatty acids were identified by comparing their retention times with those of standards. The content of volatile fatty acids was expressed as percentage of total acids.

2.4. Statistical Analysis

All the data generated in triplicates was analyzed using statistical package for social sciences (SPSS) version 16.0. Means was separated according to Duncan's multiple range analysis at $P < 0.05$.

3. Results and Discussion

Table 1 shows the physical properties. The percentage yield varied with processing. The raw oil extract had a yield of 6.14% which is lower than 7.5% reported by AOAC [15]. This could be as a result of differences in procedures, analysis and sometimes parboiled samples are used as raw because it aids dehulling, while some others process the raw sample together with the hulls. The parboiled sample had a yield of 6.62%, higher than

Table 1. Physical properties of the oil from breadfruit seed.

Parameters	Raw	Parboiled	Cooked	Toasted
Percentage Yield (%)	6.14 ± 0.1	6.62 ± 0.0	5.01 ± 0.1	7.56 ± 0.2
Colour	golden yellow	pale yellow	cloudy	brownish-yellow
Density (g/cm^3)	0.802 ± 0.1	0.899 ± 0.1	0.833 ± 0.2	0.813 ± 0.2
Moisture (%)	3.35 ± 0.02	1.88 ± 0.02	1.25 ± 0.02	8.57 ± 0.01

the raw; this probably could have been due to the heat treatment which helped to loosen the oil inherent in the seed. Temperature influence the yield of oil and better extraction is achieved by heating which reduces the oil viscosity, releases oil from the intact cells and removes moisture [22]. This is seen in the toasted oil extract which had a yield of 7.56%. From **Table 1**, the raw and toasted oil extract remained liquid at room temperature, while the parboiled and cooked oil extract were partly liquid and semi solid respectively at room temperature. The colour of the oil varied from golden yellow in the raw oil to brownish- yellow in the toasted oil. The colour of the raw oil corresponds to the report that the colour of raw African breadfruit to be yellow [23]. This is as a result of the presence of chlorophylls and carotenoid [24]. The cooked oil extract was seen to be cloudy, this could be said to be as a result of the destruction of chlorophylls and carotenoid [24]. The relative density value recorded from **Table 1** was significantly ($P < 0.05$) different. This was seen to be comparable to the values reported as 0.8656 g/ml [1] and 0.87 g/ml [25] respectively. This indicates the African breadfruit seed oil to be light especially when extracted raw.

Table 2 gives the chemical properties of the African breadfruit seed oil got through the statistical analysis. Acid value is an important index of physicochemical property of oil which is used to indicate its quality, age, edibility and suitability in industries such as in paint manufacture etc [22]. Acid values are used to measure the extent to which glycerides in the oil have been decomposed by lipase and other physical factors such as light and heat [26]. From this table, the significantly ($P < 0.05$) different acid value ranged from 9.39 mgKOH/100g in raw seed oil to 13.28 mgKOH/100g in the parboiled seed oil. This is seen to be higher than 8.41 mgKOH/100g and 3.40 mgKOH/100g reported earlier respectively [1] [27], but lower than 77 mgKOH/100g reported by [15]. This could be attributed to the number of fatty acids that were cleaved from their parent molecules. It could also be due to enzymatic activity due to micro organisms in the raw material. On the other hand, it could be as a result of difference in geographical location or extraction methods. Thus, the higher acid value of the breadfruit seed oil suggests that the oil is more susceptible to lipase action.

Peroxide value is used as a measure of extent to which rancidity reactions have occurred during storage. The peroxide value varied significantly at ($P < 0.05$) and was highest in the cooked sample (41.00 meq/kg) and lowest in the toasted sample (16.00 meq/kg). The raw sample which was 18.00 meq/kg is higher than the 4.20 meq/kg and 3.20 meq/kg (hexane extract) reported by [1] [24] respectively. This could be attributed to the mode of extraction and heat treatment the seeds were subjected to prior to extraction; since peroxidation can also be influenced by moisture (hydro peroxidation). The parboiled and cooked samples could be said to have undergone hydro peroxidation, hence their high values. Saponification value is a measure of the average molecular weight of the triglycerols in an oil sample was seen to be lowest in the raw sample (210.90 meq/kg) and highest in the cooked sample (252.34 meq/kg). This generally agrees with the report of 210 meq/kg and 259.46 meq/kg of [1] [24] respectively, thus suggesting that the mean molecular weight of fatty acid or number of ester bond is high, thus the fat molecules were intact [28]. High saponification values of 200 and above indicates high molecular weight oil good for soap and shampoo production [14].

Volatile Fatty Acid

From **Tables 3-6**, the volatile acid content was seen to vary in composition (as shown in the chromatograms, **Figures 1-4**). From the results got, heat treatment affected the composition of Formic, acetic and Propionic acid, reducing them especially in the parboiled and cooked oil samples, which could be as a result of leaching in water. There was an increase in formic and acetic acid composition in the toasted sample (**Table 6**) which could be as a result from loosening effect which toasting (dry heat) is said to have on food material to release oil [16]. Butyric acid and isobutyric acid increased considerably in all the processed samples with the highest recorded in

Table 2. Chemical properties of the oil from African breadfruit seeds.

Parameters	Raw	Parboiled	Cooked	Toasted
Acid Value (mg/g)	9.39 ± 0.1	13.28 ± 0.2	12.75 ± 0.1	10.92 ± 0.2
Peroxide Value (meq/Kg)	18.00 ± 0.00	25.00 ± 0.00	41.00 ± 2.64	16.00 ± 0.00
Free Fatty Acid	4.72 ± 0.02	6.67 ± 0.01	6.41 ± 0.01	5.49 ± 0.02
Saponification Value (mgKOH/g)	210.90 ± 0.51	230.81 ± 0.52	252.34 ± 0.57	218.75 ± 1.14

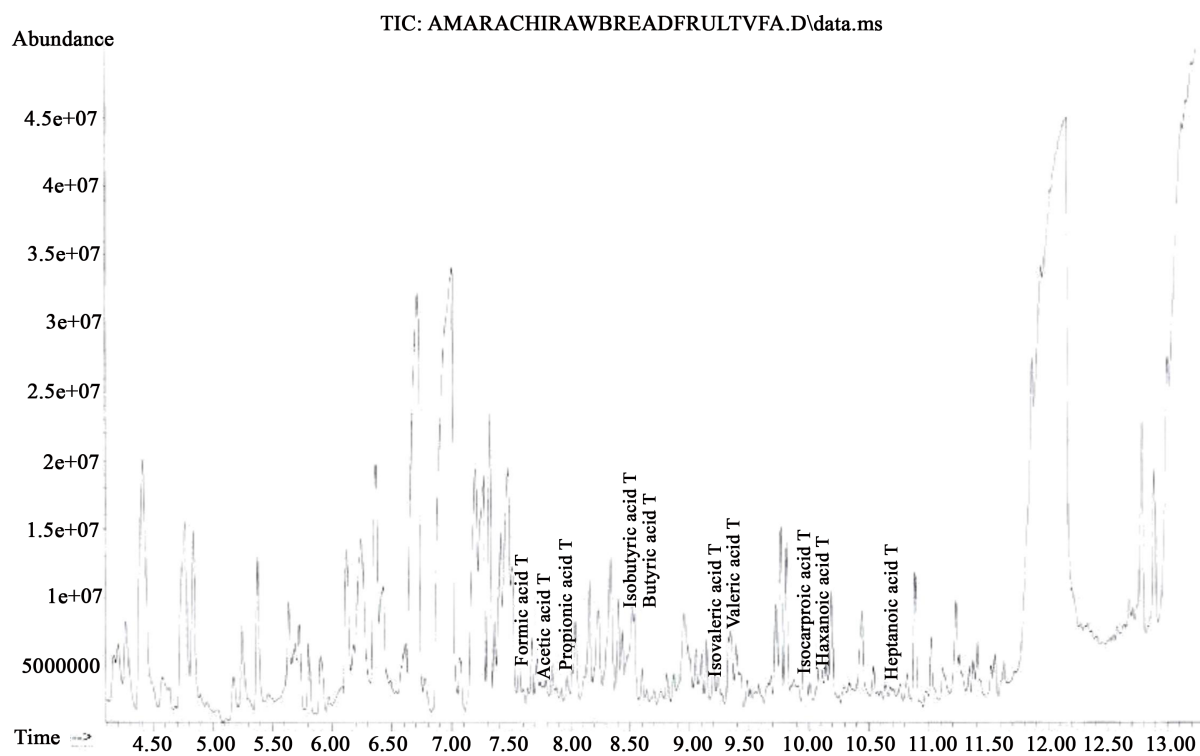


Figure 1. Chromatogram for raw African breadfruit seed oil VFA (2).

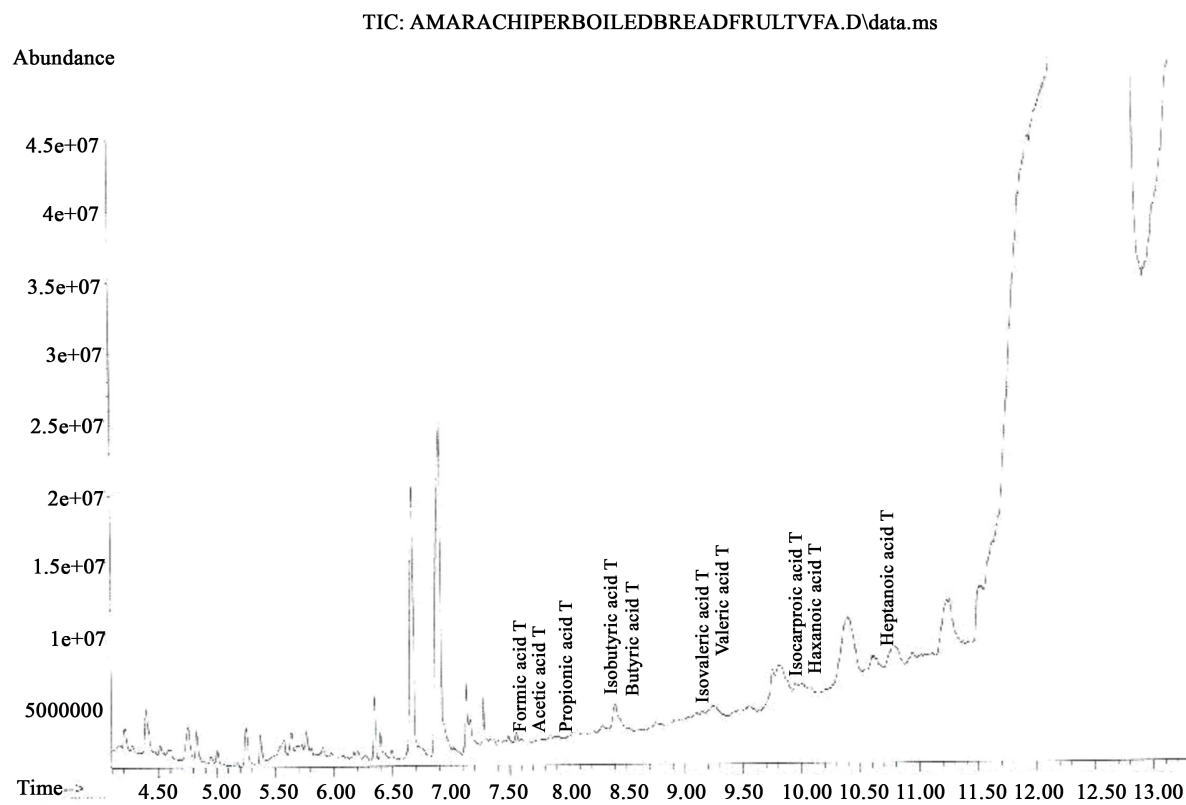


Figure 2. Chromatogram for parboiled African breadfruit seed oil VFA.

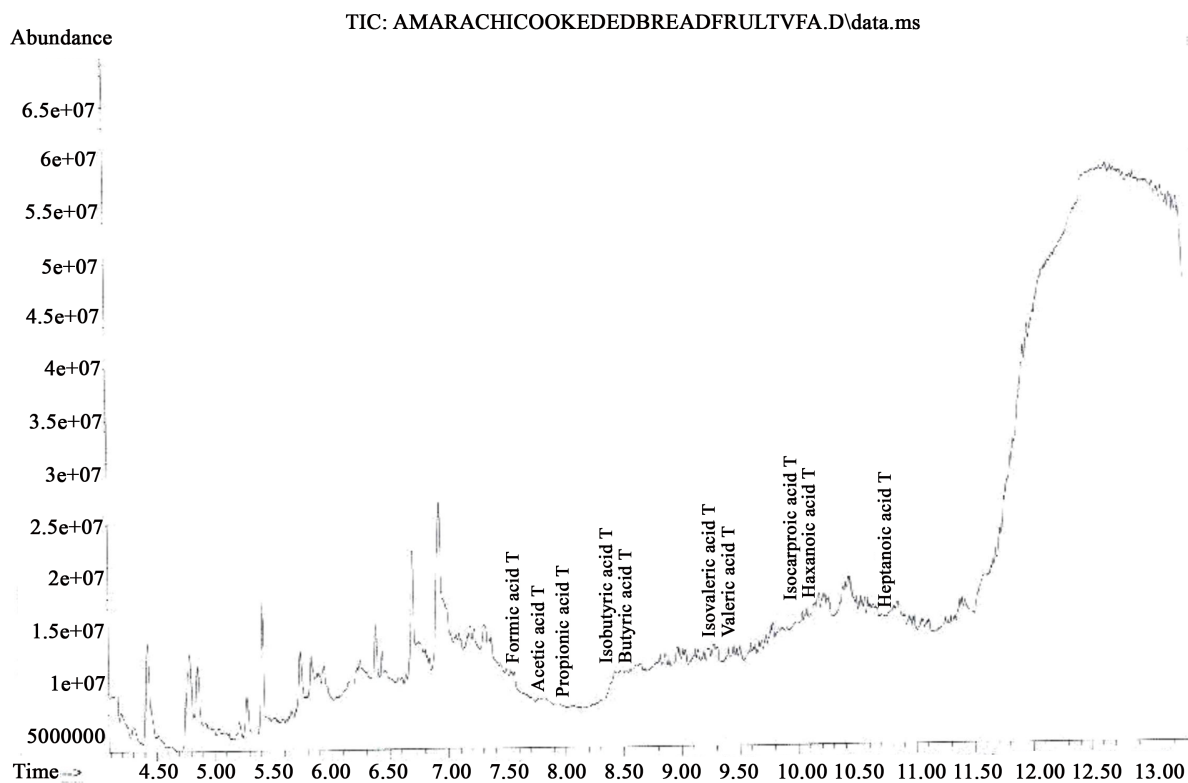


Figure 3. Chromatogram for cooked African breadfruit seed oil VFA.

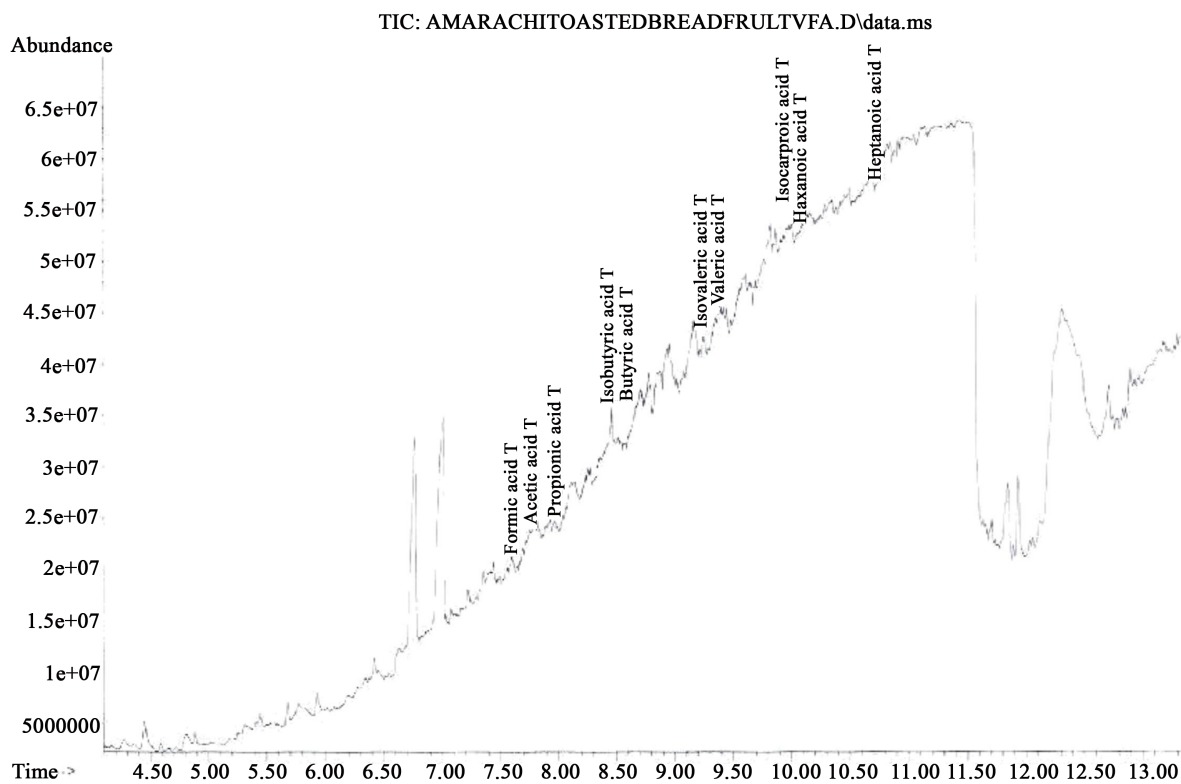


Figure 4. Chromatogram for toasted African breadfruit seed oil VFA.

Table 3. Volatile fatty acid composition of raw African breadfruit seed oil.

Compound	Formular	Retention Time (mins)	Concentration (%)
Formic Acid	CH ₂ O ₂	7.583	0.429
Acetic Acid	C ₂ H ₄ O ₂	7.766	0.647
Propionic Acid	C ₃ H ₆ O ₂	7.966	1.136
Isobutyric Acid	C ₄ H ₈ O ₂	8.516	6.90
Butyric Acid	C ₄ H ₈ O ₂	8.593	7.19
Isovaleric Acid	C ₅ H ₁₀ O ₂	9.260	0.522
Valeric Acid	C ₅ H ₁₀ O ₂	9.323	2.16
Isocaproic Acid	C ₆ H ₁₂ O ₂	10.009	2.15
Hexanoic Acid	C ₆ H ₁₂ O ₂	10.009	2.65

Table 4. Volatile fatty acid composition of parboiled African breadfruit seed oil.

Compound	Formular	Retention Time (mins)	Concentration (%)
Formic Acid	CH ₂ O ₂	7.589	0.074
Acetic Acid	C ₂ H ₄ O ₂	7.743	0.083
Propionic Acid	C ₃ H ₆ O ₂	7.983	0.066
Butyric Acid	C ₄ H ₈ O ₂	8.407	22.12
Isovaleric Acid	C ₅ H ₁₀ O ₂	9.208	4.10
Valeric Acid	C ₅ H ₁₀ O ₂	9.208	2.34
Isocaproic Acid	C ₆ H ₁₂ O ₂	9.998	9.29
Hexanoic Acid	C ₆ H ₁₂ O ₂	9.998	12.26

Table 5. Volatile fatty acid composition of cooked African breadfruit seed oil.

Compound	Formular	Retention Time (mins)	Concentration (%)
Formic Acid	CH ₂ O ₂	7.572	0.109
Acetic Acid	C ₂ H ₄ O ₂	7.783	0.332
Propionic Acid	C ₃ H ₆ O ₂	7.972	0.046
Isobutyric Acid	C ₄ H ₈ O ₂	8.430	25.83
Butyric Acid	C ₄ H ₈ O ₂	8.430	30.75
Isovaleric Acid	C ₅ H ₁₀ O ₂	9.282	0.324
Valeric Acid	C ₅ H ₁₀ O ₂	9.305	0.365
Isocaproic Acid	C ₆ H ₁₂ O ₂	9.986	1.223
Hexanoic Acid	C ₆ H ₁₂ O ₂	10.049	4.168

Table 6. Volatile fatty acid composition of toasted African breadfruit seed oil.

Compound	Formular	Retention Time (mins)	Concentration (%)
Formic Acid	CH ₂ O ₂	7.617	0.853
Acetic Acid	C ₂ H ₄ O ₂	7.743	1.243
Propionic Acid	C ₃ H ₆ O ₂	7.961	0.388
Isobutyric Acid	C ₄ H ₈ O ₂	8.458	37.19
Butyric Acid	C ₄ H ₈ O ₂	8.458	44.26
Isovaleric Acid	C ₅ H ₁₀ O ₂	9.254	2.676
Valeric Acid	C ₅ H ₁₀ O ₂	9.351	0.993
Isocaproic Acid	C ₆ H ₁₂ O ₂	10.015	10.25
Hexanoic Acid	C ₆ H ₁₂ O ₂	10.060	0.604

the toasted sample 44.26% and 37.19% respectively. VFAs especially butyric and isobutyric acid have been reported to contribute to normal large bowel function and prevent pathology through their actions in the lumen and on the colonic musculature and vasculature and through their metabolism by colonocytes. They play a role in maintaining a normal colonocyte population [29]. Isocarpic acid varied in the samples with the raw sample was containing 2.15%. The toasted sample (Table 6) had the highest value 10.25%, which could have resulted due to non involvement in moisture during processing; the parboiled sample (Table 4) had a similar high value of 9.29%, this can be as a result of high temperature-short time that could have helped to release the oil from the inner matrices. The cooked sample (Table 5) had a low value of 1.22% that may have resulted from leaching since it was processed using high temperature-long time in water. Valeric acid was also affected by temperature and mode of processing in the cooked sample (Table 5) and toasted sample (Table 6) with values 0.36% and 0.99% respectively. The parboiled sample (Table 4) was seen to increase 2.34%. Heat treatment increased Hexanoic acid in the parboiled sample (12.26%—Table 4) and cooked sample (4.16%—Table 5), but considerably decreased in the toasted sample (0.60%—Table 6). This may be due to high volatility of the hexanoic acid in the oil.

4. Conclusion

This study showed that African breadfruit (*Treculia africana*) seed oil was a good source of edible oil. Its chemical composition reflected its possible use in various industries; also the volatile fatty acid composition was seen to contain appreciable quantity of fatty acid that increased during processing, hence processing can be said to increase the volatile fatty acid content of the African breadfruit seed oil. VFA not only helps in normal body metabolism but also can improve its nutritional and economic importance; the African breadfruit seed oil is also comparable to that of some conventional oils even when processed. Therefore, the oil will do well as raw material for food and other relevant industries.

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