ACTA SCIENTIFIC NUTRITIONAL HEALTH

Volume 3 Issue 5 May 2019

Research Article

Effects of Heat Treatments of *Afzelia Africana* (African mahogany) Seed and Aril Cap on the Characeristics of the Oil

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Received: March 19, 2019; **Published:** April 05, 2019

Abstract

The effect of heat treatments of the seed and aril cap of *Afzelia Africana* on the oil on the oil was analyzed. Oil was extracted from fresh seeds and aril cap (SC and CC), toasted seed and cap (ST and CT) and boiled seed and aril cap (SB and CB) using n-hexane as extraction solvent. The various oil samples were analyzed for their physical properties: density, viscosity, percentage yield and color concentration; chemical properties: acid value, iodine value, peroxide value and free fatty acid value and amino acid profile. The result obtained showed that there was no significant difference between the viscosities and densities of the samples, the percentage yield ranged from 91.67% to 31.67% with oil from the boiled cap having the highest value and oil from the fresh seed having the lowest value. The color concentration ranged from 0.8 to 3.2 with the fresh cap having the highest value and the boiled seed having the least value. The acid value and the peroxide values of the samples reduced on heating below their controls. The reduction might be due to vaporization of the volatile components. The free fatty acid (FFA) value of the aril cap increased in both toasted and boiled samples while these reduced in the oils from the treated seed. The iodine value of the boiled aril cap reduced but increased on toasting while that of the seed reduced on toasting and boiling.

Keywords: Oil; *Afzelia Africana*; Aril Cap; Toasting; Boiling; Free Fatty Acid

Introduction

Oil and fats have been indispensible substance for mankind nutritionally and industrially. They are the most important energy source in food, and are necessary as functional constituents in the human organism and are carriers of essential nutrients important consistency and flavor in a large number of foods [1]. Oil seeds used in preparation of diets abound in Nigeria. Such seeds include; castor, coconut, dika nut, groundnut, melon, oil-bean, palm kernel, soybean, vigna and phaseolus beans cultivars and a wide variety of seeds in the *Leguminosae* family [2-5]. According to Ene-Obong and Carnovale [6], cereals and legumes in the developing countries supply the energy and vegetable proteins requirement of both humans and animals. Oil seeds serve as the ultimate sources of vegetable oil needs of the world. They are also an excellent source of protein as well as soluble dietary fiber, having relatively high quantities of Iron, Zinc, Phosphorus and exceptionally high Calcium.

Afzelia africana plants are largely cultivated in the Savannah, fringing forest and the drier parts of the forest regions of Africa. It is called Kawo, Apa, Akpalata, Anwa and Gayoki by the Igala, Hausa, Yoruba, Igbo and Fulani speaking people of Nigeria, respectively [7]. The seeds have waxy orange cap-like structure at their base and are used in Nigeria generally as soup thickening ingredient in much the same way as melon and irvingia gabonensis seeds. Proximate analysis has shown that the seed is a rich source of protein, total carbohydrate and crude fat and potassium [8]. Egwuje and Yusufu [9] had reported that the cap-like structure which is always throne away during processing is a rich source of minerals, fat and vitamins. This study therefore was aimed at evaluating the effects of toasting and boiling on the quality attributes of oil from *Afzelia africana* seed and aril cap.

Materials and Methods

Sample collection

The fresh seeds of *Afzelia africana* were purchased from the main market of Anyigba in Dekina Local Government Area of Kogi state, Nigeria.

Sample preparation

Three kilogram (3kg) of the seeds was divided into three equal parts, 1kg each having detached the orang aril. One part was roast-

ed at 1050C for 30 minutes and then de-hulled; another 1kg was cracked, boiled at 1000C for 1hour, de-hulled and sundried while the remaining 1kg was de-hulled without treatments to serve as the control. The orange aril of the seed was divided into three equal parts (100g) each. The first 100g was roasted at 1050C for 25 minutes; the second part was boiled at 1000C for 25 minutes, sundried and the third part received no treatment to serve as another control. All the samples were respectively grinded into flour prior to oil extraction.

Oil extraction

The oil was extracted using soxhlet extraction method [10]. In this method 300 ml of n- Hexane was measured into a round bottom flask. 60g of the sample was measured, wrapped with serviette paper and then inserted into the extractor and the extraction apparatus finally assembled. The soxhlet heating was done for 6hours at 40-600C which resulted to the solvent refluxing. After extraction the n-hexane was recovered from the oil using a rotary evaporator followed by degumming of the oil by wetting with water to remove phospholipids and protein complexes that are insoluble in the oil but soluble in the water. The water was decanted using a separating funnel.

Analysis of extracted oil

Some of the characteristics of oil extracted from *Afzelia afrcana* seed and aril cap such as oil yield, specific gravity, density, viscosity, saponification value, acid value, iodine value, peroxide value and free fatty acid (FFA) were evaluated according to the methods described by AOAC [11] while color component was determined by the method reported by Ariahu and Egwujeh [12]. The amino acid of the oil was determined by the methods described by [13].

Color concentration

The Spectrophotometric method was used in measuring the colour, applying Beer-Lambert equation to determine the concentration Ariahu and Egwuje [12].

$C = \log 1/T/ab$

$C = \log ab/T$

Where; a = Absorbance

b = Wavelength T = Transmittance

Amino acid profile of the oil

Ground samples were prepared for amino acid determination by acid hydrolysis with 6 NHCl for 24hrs at 110^0c in vial under vacuum and N_2 atmosphere. Sample solution was evaporated and dissolved in sodium citrate buffer (Ph 2.2). The hydrolysates were analyzed by a post column derivative method using a HPLC, which was combined with a Pickering PCX5200 derivatizer (Pickering Laboratories, Inc., USA) and ion exchange column (3.0 x 250 mm, 8um). The identification of amino acids was spectrophotometrically performed by measuring at 570nm [13].

Results and Discussion

Table 1 shows the physical properties of the oil from treated and untreated seed and aril cap of Afzelia africana.

			SAMPLES	CODES		
PARAMETER	**CC**	**CB**	**CT**	**SB**	**SC**	**ST**
Density	$0.84^a \pm 0.02$	$0.83^a \pm 0.01$	$0.82^a \pm 0.01$	$0.83^a \pm 0.01$	$0.84^a \pm 0.01$	$0.83^a \pm 0.1$
Viscosity	$26.8^a \pm 1.41$	$26.9^a \pm 1.41$	$26.8^a \pm 1.41$	$25.7^b \pm 1.41$	$26.8^a \pm 1.41$	$22.4^c \pm 1.41$
%Yield	$66.70^b \pm 0.14$	$91.67^a \pm 0.01$	$63.33^c \pm 0.01$	$33.30^e \pm 0.14$	$31.67^f \pm 0.01$	$35.00^d \pm 1.11$
Color Conc	$3.20^a \pm 0.14$	$2.40^{bc} \pm 0.14$	$2.30^c \pm 0.14$	$0.80^d \pm 0.14$	$2.40^{bc} \pm 0.14$	$2.70^b \pm 0.14$

Table 1: Physical properties of oil from boiled, toasted and fresh seed and aril cap of *A. Africana.*

CC= Oil from raw cap (control). CB= Oil from boiled cap. CT= Oil from toasted cap. SB= Oil from boiled seed. SC= Oil from raw seed (control). ST= Oil from toasted seed. Values are means of duplicate determinations. Means followed by the same superscript in row are not significantly (P>0.05) different.

The densities of CC, CB, CT, SB, SC and ST are 0.84, 0.83, 0.82, 0.83, 0.84 and 0.83 respectively. This shows that different heating method do not have significant effects (P>0.05) on the densities of A. africana seed and aril cap oils. Boiling led to a slight increase in viscosity of the oil from the cap while toasting showed no effect on the viscosity of the oil from the cap. This compared with the control. However, toasting and boiling of the seed lowered the viscosity of the oil. It might be that heating had broken the bonds in the oil thereby liquefying it hence the low viscosity.

Data showed that the aril cap contained higher amounts of oil than the seed. However, the highest volume of oil (91.67%) was from the boiled cap followed by the control of 66.70% and then the toasted sample of 63.33%. Similar observation had earlier been

reported [7]. The higher amount of oil obtained from boiled cap was an indication that wet heating of the cap resulted in better extraction of fat from the cap. According to Fellows, [14] better extraction of oil is achieved by heating the oil seed or flour to reduce the oil viscosity, release oil from intact cells and remove moisture. Lower amount of oil obtained in toasted cap could be due to losses resulting from vaporization of volatile component and or dripping of the oil during toasting.

The seed samples had lower oil volumes with the toasted sample being the highest 35.00% followed by the boiled sample of 33.30% then the control 31.67%. The yield shows that the seed and aril cap of *A. Africana* are good sources of vegetable oil being higher than 18.53% for almond seed [15], 29.39% for custard apple [16], 23.20% for African pear and [17]. The higher fat yield observed in the treated samples could be as a result of the release of oil from intact cells of the seed by heat [7]. It has been reported that any seed containing more than 17% of oil is considered to be an oil seed [18] as such *Afzelia africana* seed can be classified as an oil bearing seed, and can be utilized for the industrial vegetable oil processing.

The effect of treatments on the color concentration of the samples was determined (Table 1). It was observed that samples CB (Boiled cap, 2.4), CT (Toasted cap, 2.3), SC (Raw seed, 2.4) and ST (Toasted seed 2.3) were not significantly ($p>0.05$) different but were significantly ($p< 0.05$) different from CC (Raw cap, 3.2), SB (Boiled seed, 0.8) showing a general decrease in colour resulting from the heat treatments. The reduction in color could be due to vaporization of volatile components during heating. Similar observation had earlier been reported by Ariahu and Egwujeh [12] for fluted pumpkin and spinach leaves dried in sun and solar dryer as well as the control (raw).

Chemical Analysis

Parameter	Samples					
	CC	CB	CT	SB	SC	ST
Acid Value	$5.95^{a} \pm 0.01$	$5.05^{b} \pm 0.01$	$2.30^{c} \pm 0.01$	$0.89^{e} \pm 0.00$	$1.35^{d} \pm 0.00$	$0.90^{e} \pm 0.00$
Iodine Value	$355.96^{b} \pm 0.01$	$168.13^{d} \pm 0.01$	$398.20^{a} \pm 0.14$	$141.59^{e} \pm 0.01$	$212.38^{c} \pm 0.01$	$132.73^{f} \pm 0.01$
Peroxide	$9.240^{a} \pm 0.14$	$2.400^{d} \pm 1.41$	$2.580^{d} \pm 0.14$	$5.300^{b} \pm 1.41$	$9.300^{a} \pm 1.41$	$4.320^{c} \pm 0.14$
FFA	$5.40^{e} \pm 0.14$	$8.20^{d} \pm 0.14$	$9.30^{c} \pm 0.14$	$1.10^{f} \pm 0.14$	$10.90^{a} \pm 0.01$	$10.20^{b} \pm 0.14$

Table 2: Chemical Composition of oil from toasted, boiled and fresh seeds and aril cap of *A.africana*

CC= Oil from raw cap (control). CB= Oil from boiled cap. CT= Oil from toasted cap. SB= Oil from boiled seed. SC= Oil from raw seed (control). ST= Oil from toasted seed. Values are means of duplicate determinations. Means followed by the same superscript in row are not significantly ($p>0.05$) different.

The acid values for sample CC, CB, CT, SB, SC and ST are 5.95, 5.05, 2.30, 0.89, 1.35 and 0.90 respectively. The controls had higher values than their corresponding samples this shows that the pre heating treatment led to reduction in acid values of the oil sample. The acid values of the samples are lower than the stipulated permitted maximum values of 10 mg KOH/g oil for virgin palm [19] and 4mg/KOH/g FAO/WHO recommended value for edible oils. Thus the oil from both seed and aril cap of *Afzelia Africana* could be used for cooking [20]. The reduction in acid value of the oil which might be due to loss of volatile compounds during the heating processes of the samples could be an indication that the oil is edible Agatemor [10]. However, the low level of acid value observed in this study was an indication of low or absence of moisture hence high keeping quality [21].

- **Iodine value**: The iodine value of the samples ranged from 132.73 to 398.20 with sample CT (Toasted cap) having the highest iodine value while sample ST (Toasted seed) had the least iodine value. The high iodine value observed was a deviation from the recommended 80 – 106 FAO/WHO value for edible oils [22]. High iodine value suggests the preponderance of high molecular weight polyunsaturated fatty acids [23] which reflects the susceptibility of the oil to oxidation [24]. The high iodine value comparing to that of palm oil was an indication of high content of unsaturated fatty acids relative to palm oil [20]. This puts the oil in the semi-drying range and it can thus be used in the surface coatings industry to modify alkyd resins. This shows that the oil could be nutritionally beneficial, especially now that vegetable oils rich in polyunsaturated fatty acids and naturally occurring antioxidants are being sourced and recommended to patients that are hyper-

lipidemic or are suffering from any other lipid disorder [25]. Also, the high unsaturated fatty acid content of the seeds is of importance since they offer protective role against atherosclerotic cardiovascular disease [26].

- **Peroxide value:** The peroxide values reduced resulting from toasting and boiling of the samples been lower than their controls which were the fresh. The values conformed to the FAO/WHO recommended 10Eq/kg peroxide value for edible vegetable oils. Hydro peroxides have been identified to be the primary products of oxidation [27]. Although the oils were found to be high in unsaturation, low peroxide value was an indication that the oil might be resistant to peroxidation during storage [22]. This observation agrees with earlier reports by Arouri and Mouritsen [28] which says within that range the oil is stable and would not easily undergo rancidity.
- **Free fatty acids**: Boiling and toasting of the aril cap samples increased the FFA value while the same treatment reduced those of the seed. The increment agrees with earlier observation by Adejumo and Oyedeji [22] for fluted pumpkin seed oil. The presence of impurities could cause the hydrolysis of the ester linkage thereby increasing the free fatty acid level [29]. However, value higher than the recommended 5.78 – 7.28mg/KOH/g by FAO/WHO was a deviation. This might be an indication that the oil may have to be bleached before used for deep frying purpose just like palm oil.

Amino acids analysis

Since *Afzelia africana* seed is consumed as oil and protein food, the effects of processing methods (boiling and toasting) on its amino acid contents must not be compromised. The amino acid content of the seed and the aril cap of *Afzelia Africana* oils as affected by the processing methods are shown in Table 3 below.

AMINO ACID			SAMPLES			
	CB	CC	CT	SB	SC	ST
Histidine	$2.18^{a} \pm 0.01$	$2.11^{c} \pm 0.01$	$2.06^{e} \pm 0.01$	$2.15^{b} \pm 0.01$	$2.08^{de} \pm 0.01$	$2.10^{cd} \pm 0.01$
Threonine	$2.23^{d} \pm 0.00$	$2.28^{b} \pm 0.01$	$2.11^{e} \pm 0.01$	$2.29^{b} \pm 0.01$	$2.26^{c} \pm 0.02$	$3.06^{a} \pm 0.01$
Serine	$3.18^{c} \pm 0.01$	$2.28^{a} \pm 0.01$	$3.36^{b} \pm 0.01$	$2.88^{e} \pm 0.01$	$2.65^{f} \pm 0.02$	$3.06^{d} \pm 0.01$
Glutamic Acid	$9.65^{c} \pm 0.01$	$9.78^{b} \pm 0.01$	$9.64^{c} \pm 0.01$	$9.36^{d} \pm 0.01$	$9.87^{a} \pm 0.01$	$8.88^{e} \pm 0.01$
Proline	$2.64^{a} \pm 0.01$	$2.57^{c} \pm 0.01$	$2.47^{d} \pm 0.01$	$2.55^{c} \pm 0.01$	$2.44^{e} \pm 0.01$	$2.62^{b} \pm 0.01$
Glycine	$2.78^{a} \pm 0.01$	$2.69^{c} \pm 0.01$	$2.74^{b} \pm 0.00$	$2.64^{d} \pm 0.01$	$2.58^{e} \pm 0.01$	$2.68^{c} \pm 0.01$
Alanine	$4.02^{a} \pm 0.01$	$3.97^{b} \pm 0.01$	$3.75^{c} \pm 0.01$	$3.55^{d} \pm 0.01$	$3.18^{e} \pm 0.01$	$3.98^{b} \pm 0.01$
Cysteine	$0.69^{a} \pm 0.01$	$0.63^{b} \pm 0.01$	$0.55^{c} \pm 0.01$	$0.48^{d} \pm 0.01$	$0.55^{c} \pm 0.01$	$0.63^{b} \pm 0.01$
Valine	$3.86^{a} \pm 0.01$	$3.79^{b} \pm 0.01$	$3.65^{d} \pm 0.01$	$3.56^{e} \pm 0.01$	$3.29^{f} \pm 0.01$	$3.76^{c} \pm 0.01$
Methionine	$0.86^{a} \pm 0.01$	$0.83^{b} \pm 0.01$	$0.78^{c} \pm 0.01$	$0.64^{e} \pm 0.01$	$0.75^{d} \pm 0.01$	$0.75^{d} \pm 0.01$
Isoleucine	$3.18^{a} \pm 0.01$	$3.09^{c} \pm 0.01$	$3.12^{b} \pm 0.01$	$3.09^{c} \pm 0.01$	$3.13^{b} \pm 0.01$	$2.67^{d} \pm 0.01$
Leucine	$6.97^{b} \pm 0.01$	$6.67^{c} \pm 0.01$	$0.54^{d} \pm 0.01$	$0.48^{e} \pm 0.01$	$0.39^{f} \pm 0.01$	$7.13^{a} \pm 0.01$
Tyrosine	$2.97^{ab} \pm 0.01$	$2.79^{ab} \pm 0.01$	$2.65^{ab} \pm 0.01$	$2.54^{b} \pm 0.01$	$2.46^{b} \pm 0.01$	$3.38^{a} \pm 0.70$
Phenylalanine	$3.88^{a} \pm 0.01$	$3.67^{b} \pm 0.01$	$3.55^{c} \pm 0.01$	$3.53^{c} \pm 0.01$	$3.48^{d} \pm 0.01$	$3.37^{e} \pm 0.01$
Lysine	$3.54^{a} \pm 0.01$	$3.44^{b} \pm 0.01$	$3.26^{c} \pm 0.01$	$3.06^{d} \pm 0.01$	$2.96^{e} \pm 0.01$	$3.44^{b} \pm 0.01$
Arginine	$4.36^{a} \pm 0.01$	$4.18^{ab} \pm 0.01$	$4.08^{abc} \pm 0.01$	$3.88^{bc} \pm 0.01$	$3.67^{c} \pm 0.01$	$3.74^{bc} \pm 0.01$
Aspartic Acid	$8.34^{a} \pm 0.01$	$8.23^{b} \pm 0.01$	$8.12^{c} \pm 0.01$	$7.79^{e} \pm 0.01$	$8.03^{d} \pm 0.01$	$7.75^{f} \pm 0.01$

Table 3: Amino acids composition of oil from *A. Africana* seed and aril cap

CC= Oil from raw cap (control). CB= Oil from boiled cap. CT= Oil from toasted cap. SB= Oil from boiled seed. SC= Oil from raw seed (control). ST= Oil from toasted seed. Values are means of duplicate determinations. Means followed by the same superscript in row are not significantly ($p>0.05$) different.

All the essential amino acids that are not synthesized by human bodies but obtained from foods [30,31] are found in African oak seed and aril cap sample investigated except tryptophan that was not investigated and agrees with Mariod., *et al* [32]. Deficiency of these amino acids and some other such as cysteine, a sulphur – containing amino acids and tyrosine an aromatic amino acid might hinder healing recovery process [33].

It was observed that both boiling and toasting generally led to high amounts of the amino acids analyzed of the treated sample compared with the untreated ones. This observation agrees with Mariod., *et al*. [32], Oluwaniyi., *et al* [34]. The Histidine, Proline, Alanine, Cysteine, Valine, Methionine, Leucine Tyrosine, Phynylalanine, Lysine, Arginine and Aspartic acid components had the highest value in the boiled cap showing that boiling of the cap gave rise to increased amino acid components. However, boiling and toasting of the seed resulted in increased values of Histidine, Threonine, Serine, Proline, Glycine, Alanine, Valine, Tyrosine, Lysine and Arginine. Generally, toasting resulted in higher values of most amino acids in the oil from the seed while boiling that resulted in higher values of most amino acid components of the oil from the cap favoured the cap. These observations agreed with above observation that boiling gave higher yield of oil in the cap, indicating that the high yield of amino acids from boiled cap was a result of high yield of oil from the boiled cap. The low yield of amino acids in boiled seed might be due to inability of extraction process to separate protein from the seed optimally [35] as well as the wet heating procedure that might not be able to separate oil from the intact cells.

The aromatic amino acid (tyrosine) content of both cap and seed oils increased resulting from boiling but decreased in oil sample from toasted cap, and toasting of the seed resulted in higher value of the amino acid. The low yield of tyrosine in the toasted aril cap might be due to low yield of oil from the cap resulting from exposure to high temperature that led to burning off of the dripped oil. This agrees with observations by Abayomi., *et al.* [36], Adegoke., *et al* [37] and Mariod., *et al* [32] who reported that high temperature decreased moisture content of peanut.

Afzelia africana oil is a good source of essential amino acids notably Arginine, Glycine, Leucine, Alanine and Methionine. The other amino acids are present in moderate amounts. Cysteine is the most limiting amino acid. Adequate methionine prevents disorder of hair, skin and nail; reduces liver fat and protect the kidney [38]. Arginine is a factor for maintaining the nitrogen balance in muscles; and can enhance the lean tissue to fat tissue body fat ration; a great factor for weight management. Aspartic acid deficiency decreases cellular energy and may likely be a factor in chronic fatigue [38]. Essential amino acids in oil seeds contribute to good health and well-being. Deficiency of lycine leads to physical and mental handicap [39]. The antioxidant activity of these amino acids suggests a disease preventive role as exemplifies by arginine which is beneficial for prevention of cardiovascular disease [40]. All the values of amino acid composition of these oil proteins under study were found to be in good agreement with other varieties of oil seeds reported earlier [41-44].

It is striking to note that toasting lowered the sulphure containing amino acids (Methionine and Cystine) in both cap and seed. This was a deviation from observations by Mariod., *et al*. [32] who reported increase in these amino acids of sun flower resulting from roasting and boiling.

Conclusion

Boiling of the cap resulted in higher quantity (91.67%) of the oil than toasting (63.33%) which lowered the quantity of the oil below that of the raw (66.70%). This is because during toasting of the cap which is thin and porous in nature, the oil dripped and was burnt off resulting from absence of hull (shell). On the other hand, toasting of the seed resulted to about 35% oil than the boiled (33.3%) which were higher than the fresh (31.67%).

The heat treatments did not have significant effect on the physical properties (density, viscosity and color) of the oil.

The chemical composition of the oil shows that the Acid and peroxide value of both the Aril cap and the seed on heating reduced below their controls. Results of the chemical analysis showed that the oils from the treatments are stable to oxidative rancidity.

The amino acid profile shows that *A. africana* oil is a good source of essential and non-essential amino acids though some are in moderate quantities. These profiles show that the oils are nutritionally beneficial and healthful. Since *Afzelia africana* is consumed as protein food, effects of processing methods on its amino acids must not be compromised.

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