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EFFECT OF BOILING AND TOASTING ON THE PASTING AND FUNCTIONAL PROPERTIES OF AFRICAN OAK (*Afzelia africana*) SEEDS FLOURS.

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ABSTRACT

The effects of boiling time and toasting on starch gelatinization, pasting and functional properties of African oak seeds flour were evaluated. The seeds were divided into five portions, one portion of 3 samples were heat treated by boiling in water for 1, 2, and 3 hrs respectively, second portion was toasted (at 105^{0}C for 10 minutes) and the untreated sample as control. The samples were then milled into flours and the degree of starch gelatinization, pasting and functional properties determined. All heat treated samples increased in degree of starch gelatinization; (gelatinization increased with boiling time), pasting viscosity. Boiling for 1, 2 and 3 hours resulted in 6.67, 4.58 and 0.59 RVU breakdown viscosity while toasting resulted to 2.08 RVU, indicating that the two treatments could lead to high resistance to staleness as confirmed by low setback value (39.33, 10.58, 50.50) – a resistance to retrogradation. There was slight percentage increase in the gelation concentration from 0.20 to 0.50, emulsion 45.7 to 53.3, water absorption capacity 25-42, oil absorption capacity 11-15 and bulk density 0.63-0.68 of the flours resulting from boiling and toasting. However, the foaming capacity (50–35) and stability (100-93) of the flour samples were reduced by both the heat treatment methods. The results suggests that the seeds of African oak tree could give better flour with a wider industrial applications if they are either toasted for 10minutes or boiled for 3 hrs prior to dehulling and subsequent milling.

Keywords: African oak, pasting properties, starch gelatinization, toasting, boiling, flours.

INTRODUCTION

African oak (*Afzelia africana*) is a wild plant which belongs to the family Leguminoceae and Ceasalpinoceae subfamily (Enwere, 1998) also known as African mahogany or counter wood as well as mahogany bean tree (Burkill, 1985). In Nigeria, it is respectively known as Akparata, Apa Kawa, Anwa/Anwana by the Igbo, Yoruba, Hausa and Igala speaking people.

African oak seed is a good source of nutrients to both humans and animals. The seed contains about 27.04% crude proteins, 31.71% crude fat, 3.27% ash 33.09% total carbohydrates and 5.28% moisture (Enwere, 1998; Onweluzo, 1991; Purseglove, 1991;). The flour made from the seed is majorly used for thickening soup in Nigeria.

Starch occurs as highly organized structure known as starch granules with unique thermal properties and functionality that permits its wide use as food product and in industrial applications. Researches had shown that starches when heated in water undergo a transition process during which the granules break down into a mixture of polymers – solution known as gelatinization (Ratnayake and Jackson, 2009). Prolonged heating or pressure cooking and stirring completely dissolves all the fragments of starch granules, reducing the viscosity and as well change the rheological texture of the solution (Belitz *et al*., 2009; Cauvain and Young, 2001).

The gelatinization of starch that occurs in hot water is an important characteristic and the viscous pastes formed are influenced by the treatment it received in its primary separation from the original material. According to Cauvain and Young (2001), gelatinization temperature depends on the amount of damaged starch granules. Belitz *et al.* (2009) had reported that gelatinization temperature depends also on the equipment, amount of water, pH, type and concentration of salt, sugar, fat and protein in the recipe as well as derivative technology used. Functional properties which could affect the quality and acceptability of foods and food samples are affected by processing methods. Ikegwu *et al.* (2011) had reported that annealing, a heat treatment increased the oil and water absorption capacity of legumes starch. Information on the effects of heat treatments on the characteristics of starch from *Afzelia africana* seeds are however lacking. The aim of this study is to evaluate the effects of boiling time and toasting on the degree of starch gelatinization, functional and pasting properties of the flours of African oak (*Afzelia africana*) seeds.

MATERIALS AND METHODS

African oak seeds were obtained from Ayah in Ibaji Local Government Area of Kogi State, Nigeria. Preparation and analysis of samples were carried out in the Department of Food, Nutrition and Home Sciences, Kogi State University Anyigba and International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria, respectively.

Sample preparation

The seeds were detached from the pods, cleaned, dried and divided into five equal portions (NAAF, BAAF1, BAAF2, BAAF3 and TAAF.) NAAF which received no treatment served as control, BAAF1, BAAF2 and BAAF3 were boiled for one, two and three hours respectively while TAAF was toasted between 10 minutes at 105^{0}C. The seeds were decorticated and the boiled samples were thereafter washed and dried in the oven at 85^{0}C for 12 hours. Samples were milled (using the laboratory hammer mill), sieved (0.05 mm) and packaged in air tight plastic containers respectively (Figure 1) for analysis.

Determination of degree of starch gelatinization

The degree of starch gelatinization of the samples was carried out as described by Wooton *et al*. (1971) with slight modifications. 2 g of the sample was measured into 100ml of distilled water in a beaker and allowed to stand for 1min and then centrifuged at 1600 rpm for 10 mins. Thereafter, 1ml of the solution was diluted to 10ml with distilled water in duplicates and 0.1 ml iodine solution was added. The absorbance of the solution was taken at 600 nm using spectrophotometer (JENWAY PFP 7) and recorded as G1.

Another 2 g of the sample was measured into 95 ml of distilled water for 1 min. Thereafter, 5 ml of 10 M potassium hydroxide (KOH) was added, mixed properly and allowed to stand for 5min and centrifuged at 1600rpm for 10 mins. After centrifugation, 1ml of the solution was added to 1 ml of 0.5 M hydrochloric acid (HCl) in duplicates, diluted to 10 ml with distilled water and 0.1 ml iodine solution was added. The absorbance of the solution was now taken and recorded as G2. Percentage degree of starch gelatinization was calculated

$$G1 - \frac{G2 \times 100}{G1} \quad (1)$$

Determination of blue value index

About 1g sample was suspended in 5 ml distilled water in centrifuge tube, mixed for 1hr in boiling water bath and centrifuged at 5000 X g for 30 min. the supernatant was taken and its blue value index was determined by modified iodine method described by Birch and Prietly (1973).

Pasting properties of the flours

The pasting properties of the samples were assessed using Rapid Visco – analyzer (Newport Scientific, Australia) according to Morthy (1994).

Functional properties

The effects of boiling time and toasting on the functional properties such as foaming capacity and stability, gelation capacity, emulsion capacity and stability, water and oil absorption capacities as well as bulk density of African oak seed flour were determined.

Foaming capacity and stability

Two grammes of the flour was blended in 100ml of distilled water for 5 minutes (Onwuka, 2005) in a Kenwood blender, the mixture transferred into a 250ml measuring cylinder and allowed to stand for 30 seconds. Thereafter, foam volume was taken and percentage foaming capacity was calculated (eqn 2).

$$\% \text{ foaming capacity} = Vb - \frac{Va \times 100}{Va} \quad (2)$$

Where Va = volume before whipping, Vb = volume after whipping.

The stability of foams was monitored and recorded at intervals of 15 seconds for four consecutive times after whipping and calculated as

$$\% \text{ foam stability} = Vc/Va \times 100 \quad (3)$$

Where Vc = volume after 60 seconds (Onwuka, 2005).

Gelation capacity

One grammes of the flour was suspended in 5 ml of distil water in test tube and heated for 1hour in boiling water bath after which it was cooled under cold running tap. Further cooling for 2 hours at 40^{o}C was carried out. The test tube was inverted and the least gelation concentration was taken as concentration of the gel that did not fall.

Emulsion capacity

The emulsion capacity (EC) of the flours was determined by blending 2 g of each sample in 25ml of distil water for 30s at 1600 rpm (Onwuka, 2005). Thereafter, 25 ml vegetable oil was added and blended for another 30 seconds. The mixture was then centrifuged at 1600 rpm for 5 minutes. Percentage emulsion capacity was calculated by

$$\%EC = \frac{\text{Height of emulsified layer}}{\text{Height of whole solution in centrifuge tube}} \times 100 \quad (4)$$

Water/oil absorption capacity

One grammes of each flour sample was measured into five centrifuge tubes. 10ml distil water was added to each tube, mixed thoroughly and allowed to stand for 30 mins at room temperature after which they were centrifuged at 5000 rpm for 30mins (Onwuka, 2005). Volumes of free water were read directly from the centrifuge tubes and the average taken. The same procedure was carried out for oil absorption.

% water/oil absorption

$$= \frac{\text{Initial volume} - \text{Final volume}}{\text{Initial volume}} \times 100 \quad (5)$$

Bulk density

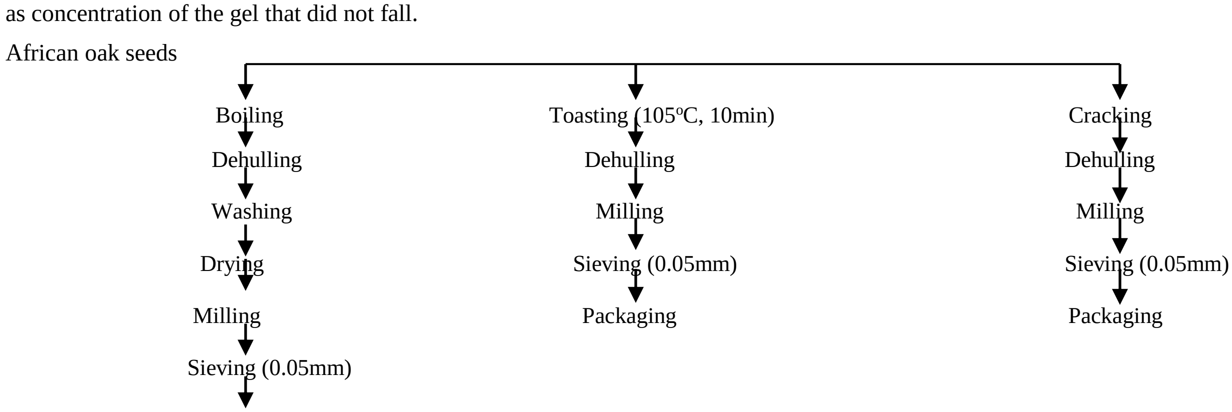
Bulk density was determined by tapping method (Onimawo and Akubor, 2012). 30 g of the sample was weighed into a measuring cylinder, tapped 100 times on the laboratory bench and the volume noted. This was repeated 5 consecutive times and average taken. Bulk density was then calculated (equation6).

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Vol. after tapping}} \quad (6)$$

RESULTS AND DISCUSSION

Degree of starch gelatinization

Table 1 shows the degree of starch gelatinization of the flour samples. The degree of gelatinization increased from 70.6 to 97.2% with increase in duration of heating (1-3hrs) and on the other hand, the samples toasted had about 92% degree of gelatinization while the untreated sample had 0%. The non-gelatinization of the control sample was in agreement with earlier reports by Ihekoronye and Ngoddy (1985) which stated that starch granules at natural state are at moisture equilibrium with their surrounding environment. When heated, the inter-molecular hydrogen bonds were disrupted allowing water to be absorbed and swelling was evident. As boiling progressed, more hydrogen bonds were loosened and additional water enters and enlarged the granules. This accounted for higher gelatinization with boiling time.



Packaging

Figure 1: Flow chart of the processing of African oak seeds into flour

Table 1. Effect of boiling time and toasting on the degree of starch gelatinization of flours of African oak seeds

Sample	G1	G2	G1/G2	G1/G2X100	Blue Value Index
NAAF	0.472	0.00	0.00	0.00^{e}	22.51±002^{d}
BAAF1		0.139	3.489	70.6±0.00^{d}	27.63±1.01^{c}
BAAF2		0.024	11.50	94.9±0.01^{b}	29.44±0.02^{c}
BAAF3		0.213	2.376	97.2±0.02^{a}	33.52±0.01^{a}
TAAF		0.036	15.667	92.4±0.00^{c}	31.84±0.10^{b}

NAAF= Untreated (control) Sample, BAAF1= Sample boiled 1hrs. BAAF2= Sample boiled for 2hrs. BAAF3= Sample boiled for 3hrs. TAAF= Sample toasted.

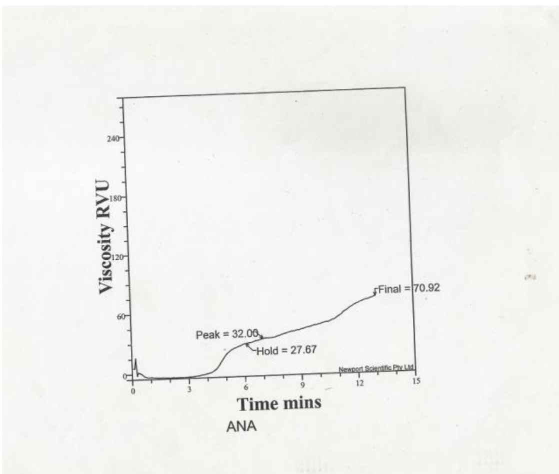


Figure 2. Pasting properties of flour (NAAF) from untreated (native) African oak seeds.

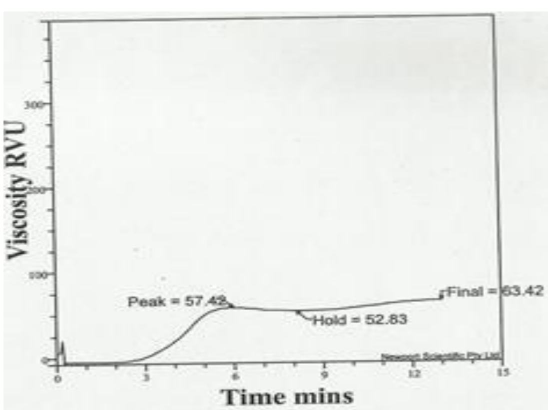


Figure 3. Pasting properties of flour (BAAF1) obtained from African oak seeds boiled for 1hour.

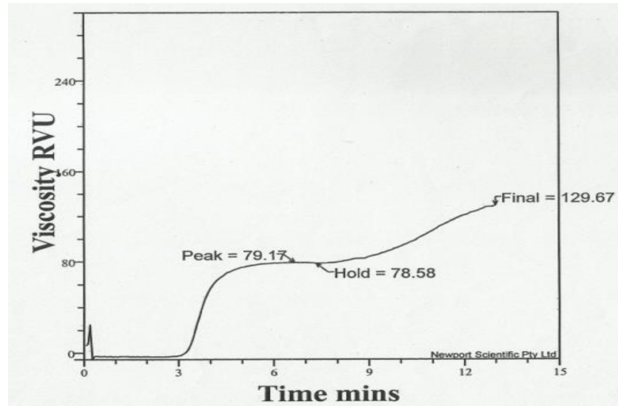


Figure 4. Pasting properties of flour (BAAF2) from African oak seeds boiled for 2hours.

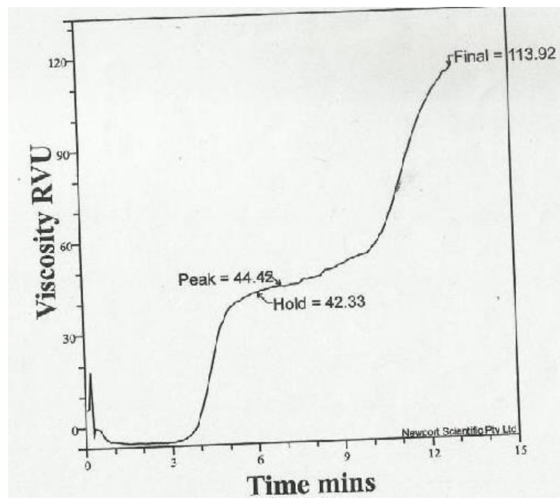


Figure 5. Pasting properties of flour (BAAF3) from African oak seeds boiled for 3hours.

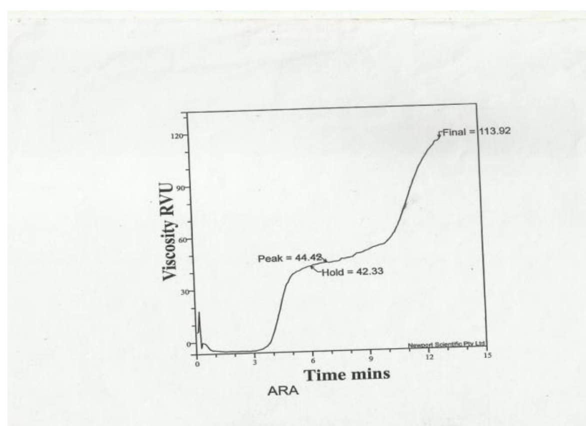


Figure 6. Pasting properties of flour (TAAF) from toasted African oak seeds.

The blue value index increased with increasing boiling time. Blue value index represents the degree of starch damage or starch fragility (Amani, *et al.*, 1993). High blue value index observed in the treated samples (27.63 – 33.52) over the untreated sample (22.51) might be attributed to higher damaged starch granules. Damaged starch granules have greater affinity for water resulting to increased water absorption and swelling (Chinma, *et al.*, 2012). These results show that in the application of African oak in foods requiring gelatinization, the seeds should be boiled for 2 to 3 hrs or toasted.

Pasting characteristics

The pasting curves of the starches are shown in Figures 2, 3, 4 5 and 6. Pasting characteristic of starches can be correlated with cooking quality and texture of various food products, hence a good index of textural quality in most starchy foods. The pasting temperature slightly increased with time of boiling. However the toasted sample had higher pasting temperature than the boiled and the native or untreated samples (Table 2). Toasting of *Afzelia africana* seeds could therefore lead to increase in its cooking temperature.

Table 2. Pasting properties of flours from boiled or toasted African oak (Afzelia africana) seed

Sample	Peak1 (RVU)	Trough1 (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak time (Min)	Pasting Temperature (^{0}C)
			4.33±0.03				
NAAF	32.02±0.02	27.67±0.07	6.67±0.03	70.92±0.02	43.25±2.25	7.00±1.00	90.22±0.22
BAAF1	98.50±0.65	91.83±0.04	4.58±0.02	131.17±1.17	71.58±0.01	6.87±0.02	84.75±0.01
BAAF2	57.42±0.01	52.83±2.03	0.59±0.01	63.42±3.00	50.50±5.69	6.00±0.50	86.78±0.01
BAAF3	79.17±0.03	78.58±0.01	2.08±0.08	129.67±0.33	39.33±0.02	5.38±0.00	85.48±0.06
TAAF	44.42±0.02	42.33±0.11		113.93±0.02	10.58±0.02	7.00±0.50	92.25±2.25

NAAF= Untreated (control) Sample, BAAF1= Sample boiled 1hrs. BAAF2= Sample boiled for 2hrs. BAAF3= Sample boiled for 3hrs. TAAF= Sample toasted.

Peak viscosity occurs at equilibrium between granules swelling which increases viscosity, granules rupture and alignment that caused decrease in viscosity. It is a measure of the ability of a starch to form paste on cooking. The peak viscosity of the treated African oak flours ranged between 44 and 98.5RVU while the control had 32.02RVU. Among the boiled samples, the samples boiled for 2hrs had the lowest peak viscosity value, showing that it cannot easily form paste. In comparison, the toasted sample (44.42RVU) had lower ability to form paste than the boiled samples. This shows that higher temperature is needed to cook the toasted African oak. However, all the treated samples had higher peak viscosities than the control, indicating that the heat treatments increased the paste forming capability of African oak seed. It could be inferred here, that the samples BAAF2 and TAAF boiled for 2hrs and toasted respectively, had lower tendencies to form paste than BAAF1 and BAAF3 boiled for 1 and 3hrs respectively. This agreed with earlier observation by Chinma *et al* (2012) for cassava starch.

Hold strength is the ability of starch granules to remain undisrupted when the paste is subjected to hold period of constant high temperature (95^{0}C for 2.30mins) followed by mechanical shear stress (rapid constant and continuous mixing). Breakdown values ranged from 0.5 – 6.67 decreasing as boiling time increased. The lower the breakdown value, the lower the hydrolysis. This means that the lower the value of the breakdown the more resistant is a paste to stainless. Chinma, *et al;* (2012) and Ragaee and Abdel–Aal (2006) had earlier reported that low breakdown value indicates high paste stability. The sample boiled for 3hrs having 0.59RVU breakdown might be of higher industrial importance.

Setback viscosities of the samples were 43.25, 39.33, 40.58, 50.50 and 71.58 respectively for the native, 1hr, 2hr, 3hr boiling and toasting. Although both treatments showed high values, the toasted sample and that boiled for 3hr had higher values and values increased with boiling time. Setback viscosity, the phase of pasting curve after cooling of starch to 50^{0}C is an indication of re-association or retrogradation of starch molecules (Chinma, et al; 2010). It is the tendency of starch to associate or dissociate. A higher setback value indicates that the paste is cohesive while lower one indicates none cohesive (Chinma *et al;* 2010, Kim *et al;* 1991). According to Chinma *et al.* (2012), Ragaee and Abdel–Aal (2006), low setback viscosity indicates low rate of starch retrogradation. High setback viscosity is also associated with syneresis or weeping (Adegunwa, 2012). The toasted and the 3hr boiled samples having higher setback values could be more stable in their pastes. These could therefore good treatments for food products requiring high setback viscosity. This implies that for foods that need no syneresis (requires retention of moisture) the seed should be boiled for 3hrs or toasted before dehulling.

Final viscosity of the native sample was 70.92RVU while those of the boiled samples were 1hr (131.17RVU), 2hr (63.42RVU) and 3hr (129.67RVU) and that of toasted sample was 113.93RVU. This increased viscosity was due to simple kinetic effect of cooling as well as re-association of molecules. It is important in predicting and defining the final textural quality of foods in terms of its hardness and elasticity. Of the boiled samples, BAAF1 (boiled for 1hr) had highest final viscosity followed by BAAF3 (boiled for 3hrs) while the toasted sample (TAAF) was third highest. The high values obtained were indications that the samples had higher molecular re-association. Chinma, *et al* (2012) had earlier reported similar observation for cassava starch. It could be inferred that boiling of *A. africana* seeds for 1hr, 3hrs or toasting could produce starch of better industrial quality than boiling of the seeds for2hrs or untreated.

The boiled samples had lower gelatinization temperatures (90.22, 84.75, 86.78, 85.48 and92.25) and peak time (7.00, 6.87, 6.00, 5.38 and 7.00) respectively for BAAF1, BAAF2 and BAAF3 than the toasted (92.25 and 7.00) and untreated (90.22 and 7.00) samples. This is an indication that the boiled samples are likely to cook more easily than the toasted and native samples (Chinma, *et al.*, 2010).

Functional properties

The effects of boiling time and toasting on the functional properties of African oak seed flour are shown in Table 3. Boiling time showed some effects on the gelation concentration (0.3 – 0.5), emulsion (52.4 – 50.0) water (25 – 42), oil absorption (12 – 15) capacities as well as bulk density (0.68 – 0.63). Toasting on the other hand reduced the foaming capacity (50 -35) and stability (100 – 97), oil absorption (12 – 11) capacities as well as bulk density (0.68 – 0.63) but no visible effect on the water absorption of the flour. Similar observations had been reported (Akubor, 2008) for treated pigeon pea. Gelling properties of legume flours play significant role in the functional properties of the flour. The flours from the boiled seeds showed good gel formation so they could be useful in food such as snacks as well puddings.

Foams are used to improve on the texture, consistency and appearance of foods (Akubor, 2008). It is related to the rate of decrease in surface tension of air – water interface caused by adsorption of protein molecules and is affected by processing method (Sathe *et al.,* 1982; Yatsumatsu *et al.,* 1972). The reduction in the foam formation (50 – 35) could be an indication that the treatments had increased the surface tension of protein molecules of the flour (Akubor, 2008). However, high foam stability (100 – 93) in boiled samples and (100 – 97) in toasted sample observed in the samples suggested that the samples were suitable for foods or food products where high porosity such as confectionaries and baked products are required. The samples from boiling of the seeds had higher water and oil absorption capacities than that from toasting. The percentage water absorption capacities of the boiled samples ranged from 30 to 42 while those of the toasted and the control were 25% respectively (Table 3). Higher oil/water absorption capacities of the boiled African oak seeds could be that the polar residues were exposed from the interior of protein molecules due to boiling (Fellows, 2009). On the other hand, lower water and oil absorption shown by the toasted seeds might be due to hardening effect of toasting on the seeds.

Table 3. Effects of boiling time and toasting on the functional properties of African oak seed flour.

Properties	**Samples**				
	NAAF	BAAF1	BAAF2	BAAF3	TAAF
Gelation cap w/v	0.20 ± 0.02^{b}	0.30 ± 0.06^{ab}	0.50 ± 0.01^{a}	0.50 ± 0.03^{a}	0.3 ± 0.01^{ab}
Foaming cap. %	50 ± 0.50^{a}	40 ± 0.50^{b}	35 ± 0.20^{c}	35 ± 0.50^{c}	35 ± 0.30^{c}
Foam stability %	100 ± 0.20^{a}	95 ± 0.20^{c}	93 ± 0.10^{d}	93 ± 0.10^{d}	97 ± 0.30^{b}
Emulsion cap. %	45.7 ± 0.20^{c}	52.4 ± 0.31^{a}	52.4 ± 0.40^{a}	50.0 ± 0.2^{b}	53.3 ± 0.30^{a}
Oil absorption cap. %	12 ± 0.20^{b}	15 ± 0.30^{a}	15 ± 0.20^{a}	15 ± 0.10^{a}	11 ± 0.10^{b}
Water absorption cap. %	25 ± 0.20^{d}	30 ± 0.40^{c}	40 ± 0.20^{b}	42 ± 0.21^{a}	25 ± 0.10^{d}
Bulk density g/v.	0.68 ± 0.02^{a}	0.63 ± 0.02^{c}	0.65 ± 0.02^{a}	0.65 ± 0.05^{b}	0.63 ± 0.02^{c}

NAAF= Untreated (control) Sample, BAAF1= Sample boiled 1hrs. BAAF2= Sample boiled for 2hrs. BAAF3= Sample boiled for 3hrs. TAAF= Sample toasted.

Emulsion capacity is the ability of a substance to form a stable emulsion by intimate mixing of two or more immiscible liquids so that dispersed phase is formed into small droplets within the continuous phase (Fellows, 2009). It was observed that the treatments improved upon the emulsion capacity (45.7–53.3) of all samples (Table 3). The average emulsion capacity shown by the treated African oak seeds flours could be an indication that they could be used conveniently in low fat foods such as ice cream, cakes etc. Onyechi *et al.* (2013) had reported diabetic snacks from the seeds of African oak and recommended its utilization in such foods.

CONCLUSION

Dehulling was made easier by toasting and 3 hours boiling of the seeds, starch gelatinization increased with increasing time of boiling and compared with toasting. Higher pasting temperature and peak time observed in toasted sample over the boiled and native samples was an indication that it would take longer time to cook although this and 3 hours boiling of the seeds resulted in improved pasting characteristics and functional properties.

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