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INTER-RELATIONSHIP OF DEHULLING AND TOASTING ON THE PROXIMATE COMPOSITION AND ATWATER FACTOR OF AFRICAN BREAD FRUIT (*TRECULIA AFRICANA*) SEEDS

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ABSTRACT: *We studied the influence of dehulling on proximate and dietary energy profiles of toasted fresh and mature breadfruit seeds. Procured bread fruit seeds were washed to remove residual slimy substance with water and sorting to remove debris, stones and immature seeds. The seeds were divided into two batches. One batch was parboiled at 100^{0}C for 15min, dehulled and winnowed after cooling to remove the hulls, and toasted in a frying pan at 45°C for 30m with constant stirring to obtain dehulled toasted bread fruit (DTB) sample. The other batch was toasted directly without dehulling at same temperature and time regime to obtain un-dehulled toasted breadfruit sample (UTB). Both samples were allowed to cool to room temperature and packed in air tight container for analyses. Proximate analysis was carried out using standard analytical procedures. Energy profiles were calculated using the Atwater factor. Results obtained showed that UTB sample had significant ($p<0.05$) higher moisture (9.59%), protein content (17.38%), ash (2.47%) and crude fat (9.76%) than DTB sample with moisture (6.39%) crude protein (16.83%), ash (2.25%) and crude fat (8.66%). The DTB sample had significant ($p<0.05$) higher crude fiber (1.44%) and carbohydrate (64.43%) contents than UTB sample respective values of .37% for crude fiber and 59.43% for carbohydrate. The DTB sample had significant higher energy value of 1643Kj/100g (390.40kcal/100g) than 1613Kj/100g (350.51kcal/100g) from UTB. The UTB retained more nutrients than DTB samples.*

KEYWORDS: Proximate Composition, Dehulling, Toasting, African Breadfruit Seeds, Atwater Factor

INTRODUCTION

African breadfruit (*Treculia africana*) seeds are highly nutritious traditional food which is not a staple food in most communities in Nigeria. The seeds are categorized as legume (Iwe and Ngoddy, 2001) with more biological value than soybeans (WAC, 2004) and higher carbohydrate and protein content than other nutrients Osabor *et al*. (2009). The seed is a cheap source of proteins, carbohydrates, fats (Enibe, 2004; Osabor *et al*., 2009), energy, carotene but low in fiber (Edet, 1982). Akubor *et al*. (2000) reported 17 to 23% crude protein, 11% crude fat and other essential vitamins and minerals. Fatty acid composition of African breadfruit seeds contains 39.3% saturated fatty acid mostly palmitic and stearic acids and 60.4% unsaturated fatty acids which are adequate to furnish most essential amino acids in the human diet with sulphur and tryptophan as the limiting amino acids (Makinde *et al*., 1985). Enibe (2004) reported 10% vegetable oil, 17% protein, and 40 % carbohydrate. Proximate analysis by Osabor *et al*. (2009) revealed 8% moisture, 12.5% crude protein, 4.2% fat, 2.3%

ash, 1.6% fiber, 73% carbohydrate, lower levels of hydrogen cyanide (0.06mg/100g), oxalate (3.0mg/100g) and phytate (0.76mg/100g). Comparative nutritional studies on dehulled and un-dehulled sun-dried seeds of African breadfruit *(Treculia africana)* also revealed that moisture (9.56%), ash (3.16%) and carbohydrate (64.95%) contents of un-dehulled are higher than that of dehulled seeds. While the crude protein (13.80%), oil (11.02%), crude fibre (1.33%) and calorific value of dehulled (436.35Kcal/g) seeds were higher than that of un-dehulled (421.57Kcal/g) seeds (Arawande *et al*., 2009).

Breadfruit seeds are mostly cooked with seasonings and eaten alone as porridge or mixed with sorghum (Onweluzo and Nnanuchi, 2009) or boiled maize (fresh or dried). The seeds could be toasted, dehulled and eaten alone or with palm kernel (*Elaeis guinensis*) as road side snack (Irvine, 1981) or with coconut. Due to popularity that necessitated higher demand of toasted dehulled seeds and the difficulties in manual dehulling after toasting, the seeds are dehulled before toasting to meet the demand. Today DTB seeds have displaced UTB which are commonly sold as street snacks. Toasted seeds are light brown in color with groundnut-like aroma. It is an important natural resource for the poor by contributing significantly to their income and dietary intake (Ogbonna *et al*., 2008). Currently, African breadfruit is processed into flour for soup and weaning food thickening, making of breadfruit cake, snacks, puddings and cookies (Umoh, 1998; Nwufor and Mba, 1998) and for medicinal uses (Osuji and Owei, 2010).

Both dehulled and un-dehulled African breadfruit seeds have short storage stability which limits their utilization. Parboiled and dehulled seeds kept up to 12 h at room temperature (Nwufor and Mba, 1998) while un-dehulled seeds are affected by long storage time and conditions, high moisture content of the seeds and high storage temperature. These result in hardening of their hulls, increase cooking time and poor product quality (Ihekeronye and Ngoddy, 1985). Besides, tannins and polyphenols (mostly in the seed coats) diffuse into the cotyledons and interfere with the nutritive value (Ekpenyong, 1985). Tannin cross links with proteins and results in post harvest seed hardening and decreased digestibility (Hentges *et al*., 1991). These limitations have made the seeds to be eaten fresh (without long storage) to preserve the nutrients for availability and removal or reduction of anti-nutrients levels which will interfere with nutrient digestion and absorption (Hassan *et al*., 2005).

Dehulling is the traditional primary processing of African breadfruit seeds during which the hulls are removed manually by gentle and repeatedly rubbing the parboiled seeds on jute sack spread on the floor or preconditioned floor with a wooden object until the seeds are completely dehulled. Manually dehulled seeds are winnowed to remove the hulls. Though this process improves the texture and other properties of the seeds, it is laborious, wasteful, time consuming and yields more split than desirable whole dehulled seeds and some un-dehulled seeds. Due to popularity and its higher demand, manual dehulling had been replaced by mechanical dehulling in Eastern part of Nigeria where African bread is relish much (Ihekoronye and Ngoddy,1985).

Toasting as another traditional method of breadfruit seed processing which involves conductive and radiative dry heating in an open pan with constant steering. Desirable flavor and colour are developed through milliard browning and caramelization due to high toasting temperature. Low temperature and short time toasting result in reduced moisture loss and tender product with poor storage stability. This work aims at investigating the influence of dehulling on the proximate and energy profiles of toasted African bread fruit seeds.

MATERIALS AND METHODS

Fresh and mature African breadfruit seeds were purchased from Ndoro market in Ikwuano Local Government area of Abia state, Nigeria.

Sample preparation: Toasting of raw African breadfruit seeds (Plate 1) was according to flow chart (Fig. 1). The seeds (Plate 1) were first manually sorted to remove extraneous materials and thoroughly washed in clean water severally to remove residual slimy jelly-like material covering the seed coats, drained and dried in the sun to remove the adhering surface water. Half of the raw seeds (Plate 1) were toasted directly without parboiling, dehulling and winnowing (Fig 1) to obtain UTB while the other half was parboiled, dehulled (Plate 2) and toasted after winnowing (Plate 3) to remove the hulls (Plate 4) and obtain DTB. Toasting of both samples was done in a frying pan at 45°C for 15m with constant stirring during which the colour turns to light brown. After toasting, both samples were allowed to cool at room temperature, packed separately in clean, dry, airtight marked containers and stored for analysis.

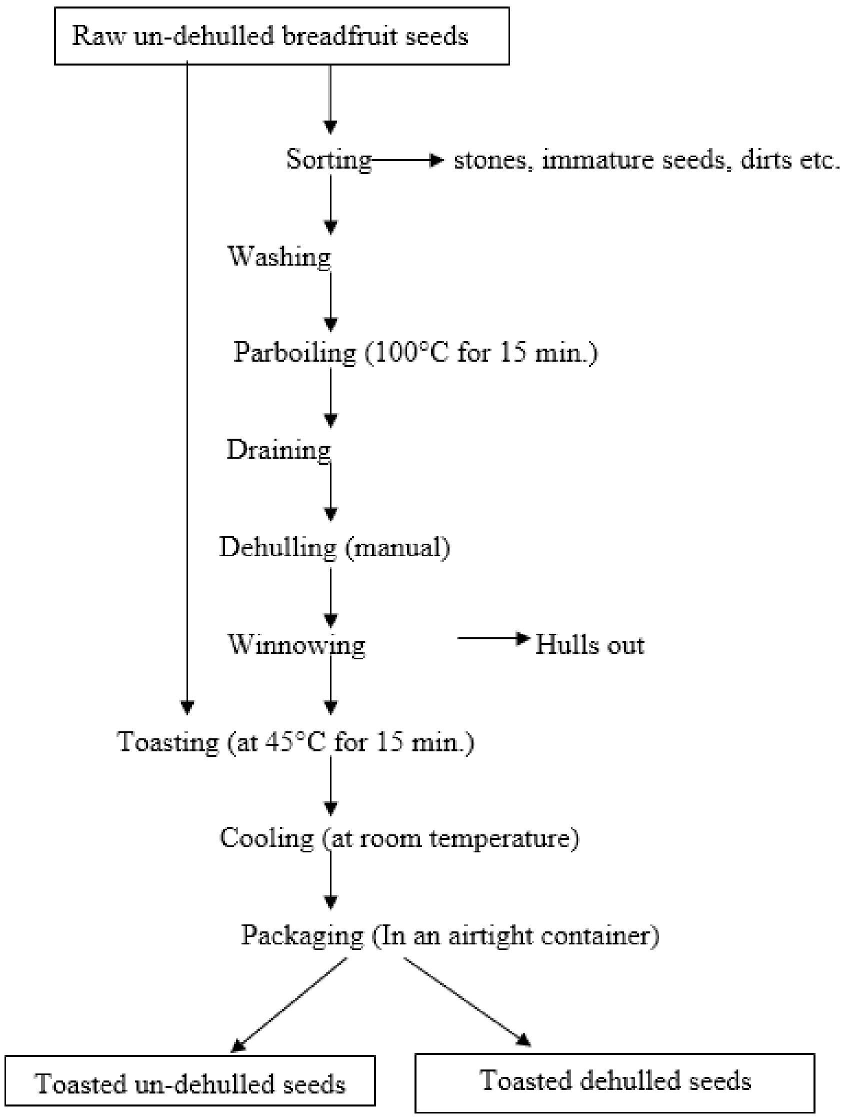

Figure 1: Flow chart for dehulled and un-dehulled toasted breadfruit seeds

Plate 1: Raw African Bread Fruit Seeds

Plate 2: Dehulled Parboiled African Bread Fruit Seeds.

Plate 3: Winnowed Dehulled African Bread Fruit Seeds

Plate 4: Hulls of African Breadfruit Seeds

Proximate Composition

Moisture content: This was determined gravimetrically according to AOAC (2000) protocol. Moisture was calculated by weight difference and expressed as a percentage of the sample weight thus:

$$\% \text{ MC} = \frac{W3-W2}{W1} \times \frac{100}{1}$$

Where: Mc =moisture content, W1=weight of sample, W2 =weight of empty can, W3=weight of dried sample + can.

Total Ash: The ash content of the sample was determined by furnace incineration gravimetric methods described by (AOAC 2000) and ash content was calculated as shown below:

$$\% \text{ Ash} = \frac{W3-W2}{W1} \times \frac{100}{1}$$

Where: W1=weight of sample, W2=weight of empty crucible, W3=weight of crucible + ash.

Fat Content: Fat content was determined by AOAC (2000) continuous solvent extraction gravimetric method using soxhlet apparatus. The weight of extracted oil was obtained as shown below:

$$\% \text{ Fat} = \frac{W3}{w2-w1} \times \frac{100}{1}$$

Where: W1= weight of empty porous paper, W2= weight of paper and sample (wrapped) before solvent extraction, W3= weight of oil sample extracted.

Crude Fiber: Weende method described by James (1995) was used for crude fiber determination using the formular:

$$\% \text{ Fiber} = \frac{w3-w2}{w1} \times \frac{100}{1}$$

Where: W_1 = weight of sample, W_2 = weight of sample after boiling + weight of crucible after drying and W_3 = weight of crucible + sample after ashing.

Crude Protein Content: Semi micro kjeldahl method described by Chang (2003) was used. Percent crude protein was obtained by $\%N_2 \times 6.25$ where

$$\% \text{ N}_2 = \frac{100}{W} \times \frac{14 \times N}{1000} \times \frac{Vd}{Va} \times T - B$$

Where W =weight of sample analyzed, N = Normality (conc.) of titrant, Vd = Total volume of digest, Va = Volume of digest analyzed, T = Titre value of sample, B =Titre value of reagent blanks.

Carbohydrate Content: The carbohydrate content was calculated by difference between 100 and a sum total of the other proximate components as described by James (1995).

Atwater Factor: The energy values of the two breadfruit samples were calculated from the energy substrates using Atwater Factor system reported by Mullan (2006).

Statistical Analysis: Data obtained were subjected to T-test analysis using the statistical package for social sciences (SPSS], version 22 .0. The results were presented as mean ± standard deviations. T-test analysis was used for comparison of the means. Differences between means were considered to be significant at $P < 0.05$ using the T-test analysis.

RESULTS AND DISCUSSION

Moisture content (MC): Results of influence of toasting before and after dehulling on proximate composition of African bread fruit are presented in Table 1.

Moisture content results showed that un-dehulled toasted breadfruit (UTB) had significant ($P < 0.05$) higher moisture (9.59%) than dehulled toasted breadfruit (DTB) with 6.39% The difference could be attributed to lewer water loss in UTB than in DTB due to presence the hulls. Moisture content result (6.39%) obtained for DTB is lower than the 8% reported by Osabor *et al*., (2009) probably due to differences in variety, soil where the tree was planted and toasting time –temperature regime. Slightly higher MC of UTB (9.59%) than 9.56% obtained from un-dehulled sun dried sample by Arewande *et al*. (2009) may mean that toasting temperature (45^0C) was higher than sun temperature. It is interesting to know that both samples had lower MC than 10% which prefigured longer shelf life most especially dehulled toasted sample when packed in airtight container. Moisture has an inverse relationship with crispiness which is a major index of acceptability of toasted breadfruit without which it may not be acceptable. On the other hand, MC aids saliva in mastication and swallowing.

Table 1: Proximate Composition of Dehulled and Un-Dehulled Toasted African Breadfruit Seeds (%).

Samples	Moisture	C/Protein	Crude Fiber	Ash	Fat	Carbohydrate
DTB	$6.39^b \pm 0.04$	$16.83^b \pm 0.10$	$1.44^a \pm 0.02$	$2.25^b \pm 0.02$	$8.66^b \pm 0.04$	$64.43^a \pm 0.05$
UTB	$9.59^a \pm 0.04$	$17.38^a \pm 0.11$	$1.37^b \pm 0.04$	$2.47^a \pm 0.01$	$9.76^a \pm 0.05$	$59.43^b \pm 0.02$

Values represent means of triplicate determinations ± standard deviations. Values on the same column with the same superscripts are not significantly different (P< 0.05), DTB = dehulled toasted breadfruit, and UTB = un-dehulld toasted breadfruit.

Protein: Significant ($P < 0.05$) higher (17.38%) protein content of UTB sample than DTB (16.83%) could be attributed to higher toasting heat in DTB sample due to absence of the hulls. The heat may have facilitated Protein-calcium interactions (Okwunodulu and Okwunodulu, 2016) and browning (Maillard reaction and caramelization) involving more DTB sample proteins thus making them unavailable during the analysis. Again, linear correlation between MC and protein had been advanced (Suite, 2018). Relatively higher protein content of both samples could be as a result of release of more bound proteins by toasting heat from their complexes with non-nutritive component by endogenous enzymes before toasting **(**Obiakor-Okeke and Nnadi 2014). Protein content obtained from DTB was lower than17 to 23% reported by Akubor *et al*. (2000) while that of UTB was slightly higher than the least value. Protein contents of both samples were higher than 12.5% reported by Osabor *et al*. (2009). The difference could be due to varietal differences, source, and temperature–time regime of the toasting. Storage period may have contributed as well (Hentges *et al*., 1991). These results show that the African breadfruit seeds have appreciable amount of protein which is in consonant with the report of Osabor *et al*., (2009). Protein complements body’s need for essential nutrients for growth, repair of worn out tissues, energy and development. Besides, protein is essential for the survival of human beings and animals (Voet *et al*., 2008).

Crude Fiber: The DTB had a significant ($p<0.05$) higher crude fiber (1.44%) than UTB with 1.37% which may stem from relatively high toasting temperature in DTB sample which may have proportionally reduced the MC and increased the fiber content. The results obtained are slightly lower than 1.6% reported by Osabor *et al*. (2009) probably due to variety, source of the samples and toasting temperature- time regime. Storage period may as well contribute (Hentges *et al.,* 1991). Lower fiber content of both samples validated lower breadfruit fiber reported by Edet (1982). Dietary fiber is an indigestible plant component like cellulose, hemicelluloses, pectin, lignins and others (Ogundele, *et al*., 2015) which lowers serum cholesterol, obesity and the healthy condition of the intestines (Rehinan *et al*., 2014) in infants and young children. Crude fiber is beneficial against colon cancers, useful in aiding bowel movement, cleanses the digestive tract by removing potential carcinogens from the body and prevents the absorption of excess cholesterol. Fiber also adds bulk to the food and prevents intake of excess starchy food and may guide against metabolic conditions such as diabetes (SFGATE, 2017). Toasted breadfruit seeds are therefore not only good snack but are also good roughage for intestinal health and weight management.

Ash Content: The UTB sample had significant higher (2.46%) ash content than DTB with 2.25% presumably due to more heat induced loss of volatile elements and intercomponent interactions in DTB sample than UTB (Nielsen, 2002; Suite, 2018). Besides, leaching of the inorganic component of the seeds during parboiling could be possible. The value obtained from UTB was slightly higher than 2.38% reported by Osabor *et al*., 2009 while that from DTB (2.25%) was slightly lower. As ash is an index of mineral content in food, therefore, both breadfruit samples can be regarded as sources of minerals required by the body for proper growth and development (Fallon and Enig, 2007).

Fat: Fat content of UTB was significantly ($p<0.05$) higher (9.76%) than that of DTB with 8.66% may be as a result of handling oil loss in DTB due to absence of hulls than in UTB sample. During toasting, the heat induced dry fat rendering by breaking of more fat cells to let more oil out which is conserved in UTB unlike in DTB sample. Also, lipase must have been activated to release bound oil in the seeds at the onset of the toasting. Both values obtained were slightly lower than 10.27% reported by Ejiofor *et al*. (1988) and higher than the 4.2% reported by Osabor *et al*. (2009) probably due to variety, storage time and toasting temperature–time regime. Breadfruit seeds contain poly-unsaturated oil which is of good heart health status, a good source of fat-soluble vitamins and other organic biological active ingredients (Weiss, 2000). Fat is a good energy substrate.

Carbohydrate: Carbohydrate content of the two samples varied significantly ($P < 0.05$) with UTB having a lower value (59.43%) while DTB had a higher value (64.43%). The discrepancy may be ascribed to the presence of hulls in UTB sample which may have protected nutrient loss due to excess toasting heat. As carbohydrate content is by difference and UTB sample had higher nutrient, therefore the carbohydrate content was lower. Besides, higher toasting heat may have induced hydrolysis of more starch to carbohydrates and simple sugars in DTB sample provided the heat is not intense and time prolonged to caramelize the hydrolyzates. This may imply that boiling and toasting are good processing methods of increasing the availability and digestibility of carbohydrate in the seeds with toasting having an edge. Carbohydrate values obtained from both samples were higher than 40% reported by (Akachukwu *et al*., 2002) which is traceable to differential nutrient composition and variety. Carbohydrate is needed in numerous biochemical reactions not directly concerned with energy metabolism. Carbohydrate levels of both samples indicated that both samples are good sources.

Atwater Factor (Energy Value): Table 2 presents the energy substrate values and their corresponding calculated energy values for DYB and UTB.

Energy value of DTB was significantly ($p<0.05$) higher 1643Kj/100g (390.43kcal/100g) than 1613Kj/100g (350.51kcal/100g) from UTB seeds. The difference may presumably come from significant (9<0.05) higher crude fiber and carbohydrate content of DTB than UTB sample Higher carbohydrate content by difference in DTB may impart be as a result of significant ($p<0.05$) lower moisture content (6.39%) of DTB than UTB (9.59%). Both energy values obtained were lower than 438.35 Kcal and 421.57 Kcal reported respectively from DTB and UTB by Arawande., *et al* (2009) but agrees with the report that DTB energy is higher than UTB sample. Interestingly, lower energy content of UTB despite significant ($p<0.05$) higher fat (9.76%) and protein (17.38%) content may mean lower energy contribution of all their energy substrates. Presence of hulls may have increased fat by conserving the dry rendered fat in UTB from handling losses. Relatively higher temperature due to absence of the hulls in DTB may have enhanced protein-calcium interaction (Okwunodulu and Okwunodulu, 2016) which may have lowered the protein content of DTB (16.83%) than UTB (17.38%). Dietary energy is an indispensible non-nutritive component of foods needed in the body for metabolic processes, physiological functions, muscular activity, heat production, growth, transport of substances around the body, synthesis of enzymes and hormones (NHMRC, 2016).

Table 2: Atwater Factors of Dehulled and Undehulled Toasted African Breadfruit Seeds (mg/100g)

	Protein (%)	Fat (%)	CF (%)	CHO (%)	Atwater kj/100g	Factors Kcal/100g
DTB	$16.83^{b}\pm0.1$	$8.66^{b}\pm0.04$	$1.44^{a}\pm\pm0.02$	$64.43^{a}\pm0.05$	$1643.03^{a}\pm2.83$	$390.40^{a}\pm0.40$
UTB	$17.38^{a}\pm0.11$	$9.76^{a}\pm0.05$	$1.37^{b}\pm0.04$	$59.43^{b}\pm0.05$	$1613.09^{b}\pm0.83$	$350.51^{b}\pm0.14$

Values represent means of triplicate determinations ± standard deviations. Values on the same column with the same superscripts are not significantly different (P< 0.05). DTB = dehulled toasted breadfruit and UTB = un-dehulld toasted breadfruit.CHO=carbohydrate, CF=crude fiber

CONCLUSION

This study revealed that toasting breadfruit seeds before dehulling is the best processing method for nutrient (protein, minerals and fat) optimization. The two samples had appreciable amount of nutrients and energy but un-dehulled toasted breadfruit seeds was higher in most of the samples. Though the moisture content was higher in un-dehulled toasted, it is lower than 10% which along with the presence of the hulls will prevent moisture loss or gain therefore will improve the shelf life better than the dehulled toasted seeds. Lower carbohydrate content of un-dehulled toasted seeds which helps to reduce the glycemic index will predispose it to managing postprandial blood glucose level in type 2 diabetic patients. Though dehulled toasted seeds had higher energy content, the difference could be easily met through other adjunct foods. Un-toasted seeds are good for the obese as it will help to reduce the problem of obesity.

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