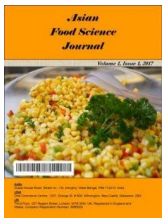

Asian Food Science Journal

9(2): 1-10, 2019; Article no.AFSJ.48397
ISSN: 2581-7752

Effects of Dehulling on the Vitamins, Minerals and Sensory Properties of Toasted African Breadfruit (*Treculia africana)* Seeds

Innocent N. Okwunodulu[1*], Peace I. Mmeregini[1] and Felicia U. Okwunodulu[2]

[1]Departement of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]Departement of Chemistry, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Authors' contributions

This is the original collaborative work among the authors. Author INO designed the study, wrote the protocol, drafted and wrote the manuscript and coordinated the entire study. Authors PIM and FUO conducted the literature searches, managed all the analyses of the study and participated in the discussion. All the authors read and approved the final manuscript for publication.

Article Information

DOI: 10.9734/AFSJ/2019/v9i230009
Editor(s):
(1) Dr. Amjad Iqbal, Assistant Professor, Department of Agriculture, Abdul Wali Khan University Mardan, Pakistan.
Reviewers:
(1) Patrícia Matos Scheuer, Santa Catarina Federal Institute, Brazil.
(2) Jana Šic žlabur, University of Zagreb, Croatia.
(3) Charles Bernard Aghadi, Nnamdi Azikiwe University, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48397

Original Research Article

Received 19 January 2019
Accepted 08 April 2019
Published 16 May 2019

ABSTRACT

Toasted dehulled African breadfruit seeds are popular snack in the south eastern part of Nigeria. Consumption of toasted dehulled seeds may result in hidden hunger due to some nutrient losses during toasting. Raw breadfruit seeds bought from the markets were sorted and divided into two batches. One batch was parboiled at 100°C for 15 minutes, manually dehulled, winnowed to remove the hulls and toasted in a frying pan at 45°C for 30 m with constant stirring to obtain crispy light brown seeds. The other batch was toasted without dehulling at same temperature-time regime and allowed to cool to room temperature before manual dehulling. Nutrient content of dehulled and undehulled toasted seeds were evaluated with standard analytical methods for nutrient losses and sensory properties to know the effects on acceptability. This study was carried out in Umuahia, Abia State capital of Abia State Nigeria between March and June, 2018. Results showed that un-dehulled toasted breadfruit (UTB) sample had significant (*P*=.05) higher vitamin A (1.62 mg/100 g),

**Corresponding author: Email: nncntokwu@yahoo.com;*

B1 (0.03 mg/100 g), B2 (0.02 mg/100 g), B3 (0.85 mg/100 g), vitamins C (2.61 mg/100/g), E (0.43 mg/100 g) than dehulled toasted breadfruit (DTB) sample with 1.47 mg/100 g, 0.02 mg/100 g, 0.01 mg/100/g, 0.76 mg/100 g, 2.44 mg/100 g and 0.37 mg/100 g respectively for vitamins A, B1, B2, B3 C and E. The UTB had significantly (*P*=.05) higher calcium (48.23), phosphorous (55.35), sodium (22.72), zinc (0.93) than DTB with respective values of 43.66, 52.67, 20.09 and 0.04 all in mg/100 g The DTB sample had significant (*P*=.05) higher potassium (336.29) magnesium (35.97) and iron (1.68) than UTB with respective values of 295.86, 32.85 and 1.53 all in mg/100 g. The UTB had significant ($p < 0.05$) higher general acceptability (7.51) than DTB (7.36). The DTB had higher loss in all the vitamins and in some mineral than DTB with better acceptability.

Keywords: African breadfruit seeds; dehulling; toasting; nutritional quality; sensory properties.

1. INTRODUCTION

African breadfruit (*Treculia africana*) tree grows widely in the high rain forest zone of Nigeria and other African countries producing enormous seeds during its fruity season (March to April). A mature tree produces approximately fifty fruits annually [1]. The common forest tree is given many names by various locations where it is found. For instance, in Igbo it is called *ukwa* which is the most popular tribal name. Other local names include *afon* by Yorubas, *ize* by Benin, *ediang* by Efik, Ibibios and Annangs and *barafutu* in Hausa [2,3].

The seeds are highly nutritious and constitute a cheap source of vitamins, minerals, proteins, carbohydrates, fats [4]. Also, mineral compositions showed that the seeds contained 710 mg/100 g sodium, 587 mg/100 g potassium, 166 mg/100 g magnesium, 1.66 mg/100 g iron, 8.50 mg/100 g zinc and 3.67 mg/100 g copper [5]. Comparative study of the nutritive significance of dehulled and fresh un-dehulled African breadfruit showed that un-dehulled seeds are richer in sodium, calcium, magnesium, and iron than dehulled seeds which was richer in zinc, copper, lead, and potassium than dehulled seeds [6].

Utilization of African breadfruit is limited by its poor storage stability resulting from higher perishable nature. Parboiled and dehulled seeds kept up to 12 hours at room temperature [7]. Long storage time and conditions, high moisture content of the seeds and high storage temperature lead to hardening of the hulls and increase the cooking time which affect product quality [8]. Diffusion of tannins and polyphenols which are more in the seed coat into the cotyledon during storage interferes with the nutritive value [9]. Also, the hydroxyl groups of the phenol ring enable the tannins cross links with proteins and results in post harvest seed hardening and decreased digestibility [10]. These limitations have made the seeds to be eaten fresh or process immediately to preserve the nutrients for availability while removing or reducing the anti-nutrients levels which interfere with nutrient digestion and absorption [11].

Dehulling is one of the primary processing methods of the seeds which involve removal of seed coat or hulls to improve the texture and other properties of the seeds. Dehulling may be manual or mechanical. In Eastern part of Nigeria where African bread is relish much, manual dehulling had been replaced by mechanical dehulling. Manual dehulling of African breadfruit seeds involves repeatedly gentle rolling of portable rectangular wooden object over the seeds on a pre conditioned floor or jute bag spread on the floor until the seeds are completely dehulled. Manual dehulling is laborious, wasteful, time consuming and yields more split than whole dehulled seeds, some undehulled seeds and hulls. Mechanical plate mill machine is used for mechanical dehulling [8]. A mechanical dehulling process for African breadfruit with over 80% dehulling efficiency had been developed [12].

Toasting of African breadfruit seeds is a heat processing method involves cooking with a combination of conductive and radiative dry heats in an open pan with constant steering. Desirable flavour and colour are developed during toasting through milliard browning and caramelization due to high to asting temperature. Also, crispy texture typical of toasted breadfruit is developed. This work aimed at investigating the effects of dehulling on the vitamin, mineral and sensory properties of toasted African bread fruit seeds.

2. MATERIALS

2.1 Raw Materials

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

2.2 Sample Preparation

Dehulled toasted African breadfruit seeds were obtained from raw seeds according to flow chart (Fig. 1). Sorted and washed raw seeds were parboiled, manually dehulled, winnowed and toasted in frying pan at 45°C for 30 min with constant stirring. Toastng un-dehulled breadfruit (Fig. 1) was direct without parboiling, dehulling, and winnowing. After toasting, both samples were allowed to cool at room temperature, packed separately in clean, dry, airtight marked containers and stored for analyses.

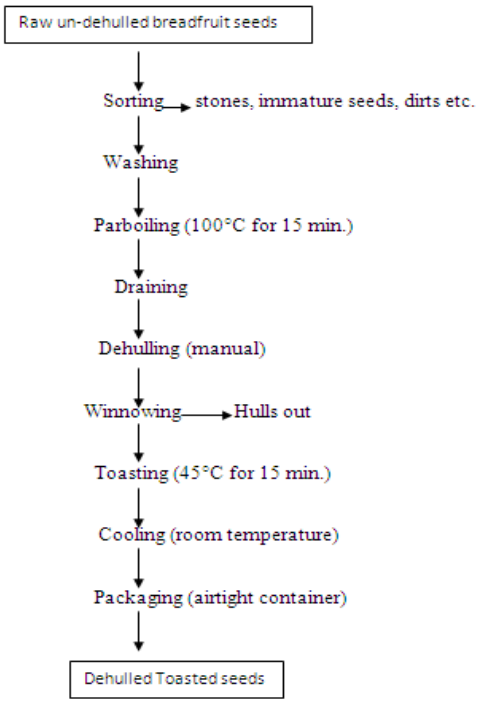

Fig. 1. Flow chart for dehulled toasted breadfruit seeds

3 METHODS

3.1 Determination of Vitamins

Spectrophotometric method was employed in the determination of vitamins A, B_1 (Thiamine), B2 (riboflavin), B3 (Niacin) and E (Tocopherol) [13] and vitamin C (ascorbic acid) [14].

3.2 Determination of Mineral

Working sample digests for analyses were prepared [15] thus. Five grams (5 g) each of DTB and UTB samples were separately burnt to ash thereafter dry ashed in a muffle furnace at 550°C for 5 hrs. The resulting ash was dissolved in 10 mls of 2M HCL solution and diluted to 100 ml in a volumetric flask using distilled water and filtered. The filtrate was used for different mineral analyses.

3.3 Phosphorous

Phosphorous in the sample digest was determined by the vanadomohybdate (yellow) spectrometry method [16] using Jenway electronic spectrophotometer at a wavelength of 420nm. Absorbance of the blank at zero was given.

Percent phosphorous content (g) for both samples were calculated by the formula:-

$$\frac{g}{100g} = \frac{100}{W} \times \frac{Au}{As} \times \frac{Vf}{Va}$$

Where: W= weight of sample analyzed, Au = absorbance of test sample, As = absorbance of standard solution, Vf = total volume of filtrate, Va = Volume of filtrate analyzed.

3.4 Calcium and Magnesium

Calcium and magnesium content of the working sample digests from both samples were determined using Versanate EDTA Complexiometric titration [15]. Percent calcium and magnesium contents were calculated separately using the formula.

$$\% \text{ Calcium or Magnesium} = \frac{100}{w} \times EW \times N \times \frac{Vf}{Va} \times T - B$$

Where:- W= weight of sample analyzed, EW = equivalent weight, N = normality of EDTA, Vf = total volume of extract, Va = volume of extract titrated, T = titre value of the sample, B = titre value of blank.

3.5 Potassium and Sodium

Flame photometry was used to determine the concentration of potassium and sodium in the

sample digest [15] and their concentrations were calculated as follows.

$$K\frac{mg}{100g} or\ Na\frac{mg}{100g} = \frac{100}{W} \times \frac{1}{1000} \times X \times \frac{Vf}{Va} \times D$$

Where:-W = weight of sample used, X = concentration (in ppm) from curve, Vf= total volume of extract, Va = volume of the extract (digest) flamed, D = dilution factor where applicable.

3.6 Zinc

Zinc content was determined using atomic absorption spectrophotometer (Buck scientific 205 atomic absorption spectrophotometer) method [17]. Sample digest from both ashes were aspirated into the atomic absorption spectrophotometer at different wave lengths during which they were converted into a free atom vapour. A monochromatic zinc source was directed through the flame and the amount of radiation of a specific energy absorbed by the solution was recorded. A calibration graph was then prepared for the element and from which the amount of the element present in each sample was read. Zinc content of the sample was calculated as shown below.

$$\text{Zn (mg/100 g)} = \frac{100}{W} \times \frac{X}{100} \times \text{D}$$

Where:-W= Weight of the sample analyzed, X= Equivalent concentration (ppm) derived from the standard curve and D= Dilution factor.

3.7 Dietary Iron

Just like in zinc, atomic absorption spectrophotometer (Buck scientific 205 atomic absorption spectrophotometer) method [17] was used to determine dietary iron content sample digest of both samples as shown below.

$$\text{Fe (mg/100 g)} = \frac{100}{W} \times \frac{X}{100} \times \text{D}$$

Where:-W=Weight of the sample analyzed, X= Equivalent concentration (in ppm) derived from the standard curve and D= Dilution factor.

3.8 Sensory Evaluation

Sensory evaluation was carried out on both toasted samples within an hour after toasting. A 25 semi-trained panelists were selected from males and females staff and students of Michael Okpara University of Agriculture Umudike between the ages of 20 to 40 yrs who are familiar with toasted breadfruit seeds. The samples were coded and randomly presented to the panelists in the same type of saucers with bottled water to rinse their mouths between each evaluation. They were instructed to chew one sample and rinse their mouths with water provided before the next. Thereafter, they were to evaluate their flavour, crispiness, taste, chewiness, overall acceptability, and rank the attributes according to 9-point Hedonic scale where 1 represented “dislike extremely” and 9 ‘like extremely”.

3.9 Statistical Analysis

Data obtained were subjected to T-test analysis using the statistical package for social sciences (SPSS], version 22.0. The triplicate results obtained 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.

4. RESULTS AND DISCUSSION

4.1 Vitamin Content

All the vitamin content results of both samples are presented in Table 1.

4.1.1 Vitamin A

There was significant (*P* =.05) vitamin A increase from 1.47 mg/100 g in DTB to 1.62 mg/100 g in UTB sample. Lower vitamin A content in DTB may have resulted from parboiling and higher toasting heat due to absence of hull which resulted in more vitamin A loss. The hull may have prevented excess heat into the seeds in UTB samples. Losses of vitamins had been reported during processing operations such as soaking, boiling, toasting and others [18]. Significant difference (*P* =.05) in vitamin A content between the samples may mean that coupled heating effects of parboiling and toasting with absence of hulls had significant destructive effects in vitamin A. Vitamin A is a fat soluble vitamin that is good for healthy vision, skin, bones and other tissues. It works as an antioxidant and fights against cell damage among others [19]. Consumption of toasted breadfruit seeds along with other vitamin A rich

foods will help to meet the RDI of 600 to 700 µg for adult of both sexes [20].

4.1.2 Vitamin B

Respective UTB sample vitamins B1, B2 and B3 values of 0.03 mg/100 g, 0.02 mg/100 g and 0.85 mg/100 g were significantly (*P*=.05) higher than those of DTB with respective values of 0.02 mg/100 g, 0.01 mg/100 g and 0.76 mg/100 g. However, higher vitamin B retention of UTB sample than DTB may be attributed to presence of hull which may have protected the seeds from excess toasting heat as well as of parboiling and leaching of same into parboiling water. Vitamin B is a water soluble mineral tied to low stroke risk, good health and promotion of healthy metabolism. While vitamin B1 prevents Beriberi and B2 boosts immune system and helps the body make up red blood cells; vitamin B3 breaks food into energy [21]. Though toasted breadfruit is not a good source of B vitamins, but will help to meet the RDI when taken as an adjunct [22].

4.1.3 Vitamin C (ascorbic acid)

The UTB sample recorded a significant (*P*=.05) higher vitamin C value of 2.62 mg/100 g than DTB with a lower value of 2.44 mg/100 g. The difference just like other vitamins may be attributed to heating effects of parboiling and toasting which were more severe due to absence of hull resulting in more vitamin C content loss in DTB than in UTB sample. Vitamin C is heat labile [23] and a major water soluble antioxidant within the body [24] that is required in small amount (few mg to a 100 mg). Due to general low vitamin C in both samples, toasted bread fruit seeds should be eaten with other vitamin C rich foods or snacks. Vitamin C is generally used for protein metabolism and collagen synthesis. Antioxidants such as vitamin C and carotenoids coupled with dietary fiber have been associated with prevention of nutritionally related diseases such as obesity, coronary heart disease [25]. Vitamin C also contributes to several key oxidative and reductive enzyme system and also has the ability to regenerate other biologically important antioxidants such as glutathione and vitamin E into their reduced state [26].

4.1.4 Vitamin E

Vitamin E content of UTB sample (0.44 mg/100 g) was significantly (*P*=.05) higher than DTB (0.37 mg/100 g). The difference may stem from significant loss due to excess heat resulting from parboiling and toasting as a result of absence of hulls in DTB sample. This may mean that the hulls in UTB may have provided significant protection against parboiling and toasting heat. Vitamin E is a fat soluble vitamin that is used among others for respiratory infections, infertility, impotence, chronic fatigue syndrome, prevention of allergies and heart diseases [27]. Regular consumption of toasted breadfruit along with vitamin E rich fatty foods will aid in meeting vitamin E RDI of 20 µg [28].

4.2 Mineral Composition

Mineral content results of DTB and UTB samples were presented in Table 2.

4.2.1 Calcium

The UTB had a significant (*P*=.05) higher calcium content of 48.23 mg/100 g than DTB with a value of 43.66 mg/100 g. The difference may have stemmed from leaching of calcium into cooking water during parboiling [29]. Also, it may mean that the hulls may have contained calcium which was removed in DTB sample. Calcium constitutes a large proportion of the bone, blood and extracellular fluid and is necessary for normal functioning of cardiac muscles, blood coagulation, milk clotting and regulation of cells permeability [30]. Though toasted breadfruit is not a good calcium source but can complement calcium content of some foods to meet the RDI of 1000 to 1300 mg/day [31] when taken as adjunct.

Table 1. Vitamin content of dehulled and un-dehulled toasted African bread fruit seed (mg/100 ml)

	Vitamin A	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin C	Vitamin E
DTB	1.47^{b}± 0.01	0.02b±0.00	0.01^{b}± 0.00	0.76^{b}±0.01	2.44^{b}±0.02	0.37^{b}±0.01
UTB	1.62^{a}±0.03	0.03^{a}±0.00	0.02^{a}± 0.00	0.85^{a}±0.01	2.61^{a} ± 0.02	0.44^{a} ±0.02

Data represent the mean ± standard deviation of the readings. All the values on the same column with the same superscripts are not significantly different (P< 0.05). DTB = de-hulled toasted breadfruit, and UTB = un-dehulled toasted breadfruit

4.2.2 Phosphorous

Phosphorous content of UTB (55.96 mg/100 g) was significantly (*P*=.05) higher than 52.67 mg/100 g from DTB probably during toasting as phosporous had been advanced as volatile element liable to loss during heating [32]. Leaching of phosphorous into the parboiling water may have contributed to the difference as well. Phosphorous may be present in the hulls which were removed during dehulling. Phosphorous is an essential mineral primarily needed for growth and repair of body cells and tissues and can complement other phosphorous rich foods in meeting the RDI of 700 mg/day [33].

4.2.3 Magnesium

Magnesium content of DTB (35.79 mg/100 g) was significantly (*P*=.05) higher than 32.85 mg/100 g from UTB. The values were lower than 166 mg/100 g [4] for raw breadfruit seeds which may be due to processing methods employed, variety and source. Higher magnesium content of DTB than UTB may be due to more loss of moisture thereby increasing the proportion of magnesium. Magnesium functions as a co-factor of more than 300 different enzyme systems of the body. It is indispensable in the formation and use of high energy phosphate bonds known as ATP. It is needed for healthy bones and blood vessels, and essential in nerve and muscle activity [34]. Toasted breadfruit especially UTB sample could be a complementary source of magnesium if taken along with other magnesium rich foods to meet magnesium RDI of 310 to 420 mg/day [35].

4.2.4 Iron

The DTB sample had significant (*P*=.05) higher iron value of 1.68 mg/100 g than 1.53 mg/100 g from UTB which may stem from the differential processing methods employed which may have prevented iron loss. Exposure to higher heat in DTB samples may have decreased the moisture more thereby increasing the iron proportion. The DTB iron value obtained was slightly higher than 1.66 mg/100 g [5] while that of UTB was lower probably due to variety and methods employed. Iron is a micro mineral necessary for formation of hemoglobin that carries oxygen in the blood and myoglobin to muscle tissues. Iron also helps in energy production and healthy immune system. The DTB is a better complementary iron source than UTB. When taken as a snack after meal will complement iron RDI of 10 to 18 mg/d [36].

4.2.5 Potassium

The DTB had potassium content of 336.29 mg/100 g is significantly higher than 295.86 mg/100 g from UTB sample. All the results were lower than 587 mg/100 g [5] probably due storage period before procuring them, processing methods and seed variety. Effects of storage on breadfruit quality had been reported [8,9]. Dehulling, variety and source may have contributed to the cause of increase. Proportional increase due to more loss of water may not be left out. Potassium, the most abundant mineral compare to others plays the role of controlling skeletal muscle contraction, nerve impulse transmission, helps to relief strokes, high blood pressure, kidney disorder, anxiety and stress. Potassium helps to balance body fluids, enhances muscle strength, metabolism and proper metabolism [37]. Toasted breadfruit especially DTB when taken as adjunct food will aid to regulate body fluid balance and proper metabolism.

4.2.6 Sodium

Significant (*P*=.05) higher sodium content of UTB sample (22.77 mg/100 g) than DTB sample (20.08 mg/100 g) may be due to leaching into parboiling water and dehulling. The hulls may have contained some sodium. Both values obtained were lower than 710 mg/100 g [5] for breadfruit seeds probably due to the processing methods adopted storage period before processing and variety of seeds used. However, the body requires a small amount of sodium to help maintain normal blood pressure, osmotic pressure, transmission of impulse, absorption of glucose and acid-base balance [38]. The levels of sodium in both samples will contribute to the above health benefits.

4.2.7 Zinc

Zinc content from UTB sample (0.93 mg/100 g) recorded significant (*P*=.05) higher value than 0.82 mg/100 g from DTB. Higher zinc value of UTB than DTB may mean that hulls may have contributed significantly in retaining zinc. Volatile nature of zinc in dry ashing had been acknowledged [32]. Also, zinc may have leached into parboiling water in DTB sample. Both values obtained were relatively lower than 8.50 mg/100 g [5] for raw breadfruit seeds which may have validated that variety, source, dehulling and parboiling have significant influence in retaining zinc in toasted breadfruit. Storage effects may

Table 2. Mineral composition of dehulled and undehulled toasted African breadfruit seeds (mg/100 g)

Samples	Calcium	Phosphorous	Magnesium	Iron	Potassium	Sodium	Zinc
DTB	43.66^{b}±0.18	52.67^{b} ± 0.18	35.97^{a}±0.18	1.68^{a}±0.06	336.29^{a}±11.75	20.09^{b}±0.7	0.83^{b}±0.04
UTB	48.23^{a}±0.81	55.35^{a}±1.27	32.85^{b}±0.07	1.53^{b}±0.01	295.86^{b}±1.41	22.72^{a}±0.09	0.93^{a}±0.01

All the values represent the mean ± standard deviation of the readings. 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

Table 3. Sensory scores of DTB and UTB African breadfruit seeds samples

Samples	Appearance	Flavor	Crispiness	Taste	Chewiness	General A
DTB	6.51^{b} ± 0.01	6.48^{b}±0.02	7.15^{b} ± 0.05	7.07^{b}±0.03	7.25^{a} ± 0.04	7.36^{b} ± 0.02
UTB	7.75^{a}±0.02	7.51^{a}±0.02	7.51^{a}±0.02	11.03^{a}±0.03	7.23^{b}±0.03	7.51^{a}±0.98

All the values represent the mean ± standard deviation of the readings, Values on the same column with the same superscripts are not significantly different (P< 0.05), DTB = dehulled toasted breadfruit and UTB = un-dehulled toasted breadfruit. A = acceptability

have contributed too. Zinc plays a significant role in cell division, cell growth, wound healing and in breakdown of carbohydrate. It is needed for the senses of smell and taste during pregnancy, infancy and childhood. Body needs zinc for growth and proper development [39]. Zinc is needed for the body's defensive (immune) system to work properly and protects liver from chemical damage. Zinc deficiency may decrease the ability of the immune system to function [40].

5. SENSORY SCORES OF THE BREADFRUIT SEEDS

Results of sensory scores of the toasted breadfruit are presented in Table 3.

5.1 Appearance

The appearance of the UTB sample was scored 7.75 by the panelists which is significantly (*P*=.05) higher than 6.52 from.DTB. Higher preference of UTB sample than DTB may be attributed to higher heat exposure to tannin content of DTB sample than UTB resulting in undesirable deep brown colour. Tannins had been reported to cause browning or other pigmentation in both fresh foods and processed products [41]. This may have given the UTB sample desirable uniform browning that attracted higher rating. Besides, sudden higher moisture loss in DTB than in UTB sample due to absence of hulls may have resulted in shrink seed surfaces thereby affecting the general seeds appearance.

5.2 Flavour

The UTB sample was rated 7.51 by the panelists which was significantly higher than 6.48 rating of DTB. The difference may be attributed to hulls in UTB sample which may have prevented the volatile compounds from escaping during toasting. The hulls also may have imparted some desirable flavor to the seeds of UTB samples during toasting. Besides, more volatile components of DTB sample may have escaped during parboiling and toasting. Dry rendered fat in UTB sample was not lost but was retained by the hulls to add to the flavour.

5.3 Crispiness

The test panelists rated UTB sample 7.51 which was significantly (*P*=.05) higher than 7.15 from DTB. This implies that UTB sample was most preferred by the test panelist. However, this may be due to the presence of the hulls which may have prevented the seed from loosing excess during toasting or gaining moisture from the environment after toasting. On the other hand, excess water loss by DTB sample resulted in dried product with relatively undesirable crispiness. Moisture has an inverse relationship with crispiness which is a major index of acceptability in toasted breadfruit without which it may not be acceptable.

5.4 Taste

The taste of UTB was more preferred by the panelists with a rating of 7.67 which was significantly (*P*=.05) higher than 7.07 from DTB sample. Preference of UTB sample to DTB could be attributed to higher flavour recorded by UTB. Flavour is a combination of taste and aroma. The hulls of UTB sample may have prevented the escape of volatile components and dry rendered fat of the UTB sample thereby increased the flavour.

5.5 Chewiness

Higher chewiness score of UTB (7.32) by the panelists was significantly (*P*=.05) higher than 7.25 from DTB sample. This may be due to significant higher crispiness of UTB than DTB which was harder and brittle to chew due in part to relatively higher moisture loss during toasting. Desirable chewiness hinges on crispiness which in turn has an inverse relationship with moisture.

5.6 General Acceptability

The UTB sample was preferred to DTB by the panelist with 7.51 rating which was significantly (*P*=.05) higher than 7.36 from DTB. Preference of UTB to DTB could be better explained by higher significant ($p<0.05$) difference of UTB than DTB in all the attributes tested.

6. CONCLUSION

The results of this study showed that toasted un-dehulled breadfruit seeds are the best since they have higher nutrients with better acceptability and shelf stability. Ash, fat, fiber, protein, carbohydrate, vitamins and minerals content were higher in the un-dehulled toasted seeds. Therefore, toasting before dehulling is still the best processing method for African breadfruit seeds in terms of nutrient retainsion.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nwabueze TU, Iwe MO, Akobundu ENT. Physical characteristics and acceptability of extruded African breadfruit based snacks. Journal of Food Quality. 2008;31(2):142-155.
2. Irvine JI. Comparative study of the chemical composition and mineral element content of *Treculia africana* seed oils. Journal of Food Engineering. 1981;40:241-244.
3. Keay RWJ. Trees of Nigeria. Clarendon Press Oxford. USA Nordic Journal Botany. 1989;2(3):322.
4. Osabor VN, Ogar DA, Okafor PC, Egbung GF. Profile of the African breadfruit (*Treculia africana*). Pakistan Journal of Nutrition. 2009;8(7):1005-1008.
5. Makinde MA, Elemo BO, Arukwe U, Pellett P. Ukwa seed (*Treculia africana Decne*) protein 1. Chemical evaluation of the protein quality. Journal Agriculture and Food Chemistry. 1985;33(1):70-72.
6. Arawande JO, Ajayi IO, Adewumi BL. Nutritional significance of husked and dehusked seeds of African breadfruits and characterization of its extracted oil. Department of Biochemistry, University of Benin. 2009;1:84-130.
7. Nwafor MI, Mba PC. Studies on post harvest roots of African breadfruit (*Treculia africana)* seeds in Nigeria. J. International Biodeterioration. 2000;24:17-23.
8. Ihekoronye AH, Ngoddy PO. Nutritional composition of African breadfruit (*Treculia africana*). Nigerian. Journal of Nutrition Science. 1985;29:190-191.
9. Ekpenyong TE. Chemical composition and amino acid content of African breadfruit (*Treculia africana Decne*). Food Chemistry. 1985;17:59-64.
10. Hentges DL, Weaver CM, Nielsen SS. Changes in selected physical and chemical components in the development of the hard-to-cook bean defect. Journal Food Science. 1991;56:436-442.
11. Hassan AB, Osman GA, Babiker EE. Effect of domestic processing on anti-nutrients and availability of protein and mineral of lupin (*Lupinus termis*) seeds. Journal of Food Technology. 2005;3:263-8.
12. Iwe MO, Ngoddy PO. Development of mechanical dehulling process of the African breadfruit (*Treculia africana*). Nigeria Food Journal. 2001;19:8-16.
13. Onwuka GI. Food analysis and instrumentation: Theory and practice. 1st Edn, Napthall. Prints. Surulere,. Lagos-Nigeria. 2005;140-160.
14. Okwu DE, Josiah C. Evaluation of the chemical composition of two Nigerian medicinal plants. African Journal of Biotechnology. 2006;5(4):357-361.
15. Carpenter CE, Hendricks DG. Mineral analysis. In: S.S. Nielsen (Ed.) Food Analysis. 3rd. Springer LLC, New York, NY. 2003;198–206.
16. James CS. Analytical chemistry of food. Chapman and Hall, London. Journal of Research in National Development. 1995;7(1):64-65.
17. AOAC. Official methods of analysis. Association of Official Analytical Chemist. 18th Edition. Washington DC. USA; 2000.
18. Badejo FMS. Introduction to food science and technology, i/c Kitamas Academic and Industrial Publishers, Ilorin, Kwara State Nigeria. 1999;105-108,115–122. Available:www.iosrjournals.org
19. Bradford A. Vitamin A: Sources and benefits-live science; 2015. Available:http://www.livesscience.com/51975.vitamin-ahtml
20. Olson JA. Recommended dietary intakes (RDI) of vitamin A in humans. The American Journal of Clinical Nutrition. 1987;45(4):501-512.
21. Everyday Health 8. Comprising benefits of B vitamins; 2018. Available:http://www.everydayhealth.com/pictures/surprising-health-benefits-b-vitamins/
22. LENNTECH. Recommended daily intake of vitamins and minerals; 2018. Available:http://lenntech.com/recom
23. Fallon S, Enig MG. Nourishing tradition in: The Cookbook that challenges politically correct nutrition and the diet dictocrates. NewTrends Publishing Inc.; 2007. Available:www.Newtrendpublishing.com
24. Rahman Khan MM, Rahman MM, Islam MS, Begum SA. A simple UV-spectrophotometric method for the determination of vitamin C content in various fruits and vegetables at Sylhet

Areas in Bangladesh. J. Biological Science. 2006;6(2):388-392.
25. Larsson M, Rossande-Hulthen L, Sandstome B, Sandberg A. Improved iron and zinc absorption from breakfast meals containing malted oats with reduced phytate content. British Journal of Nutrition. 1996;76:677-688.
26. Jacob RT, Pattabiraman TN. Natural plant enzyme inhibitors: Isolation and properties of a trypsin / chymotrypsin inhibitor from kidney bean (*Phaseolus vulgaris).* Indian Journal Biochem. Biophys. 1995;23:105-109.
27. WebMD. Vitamin E; 2018. Available:http://www.webmd.com/vitamins/ai/ingredient-954/vitamine
28. NIH=National Institutes of Health Office of Dietary Supplement; 2018. Available:http://www.webmd.com/vitamins/ai/ingredient-954/vitamine
29. Ijeh II, Chukwunonso ECC, Ejike O, Nkwonta MB, Njoku C, Effect of traditional processing techniques on the nutritional and phytochemical composition of African breadfruit (*Treculia africana*) seed. Journal Applied Science Environment. 2010;14(4): 169-173.
30. Ogbuewu IP, Jiwuba PD, Ezeokeke CT, Uchegu MC, Okoli IC, Illoeje MU. Evaluation of phytochemical and nutritional composition of ginger rhizome powder. International Journal of Agriculture and Rural Development. 2014;17(1):1663-1670.
31. FAO/WHO (Food and Agriculture Organization/World Health Organization). Human vitamin and mineral requirements. Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Division, FAO Rome. 2001;161-162.
32. Nielsen SS. Mineral analysis by traditional methods. In: Introduction to the Chemical Analysis of foods CBS Publishers and Distributors, New Delhi-110032 India. 2002;125-135.
33. Healthline. Top 12 Foods that is high in phosphorus; 2018. Available:http://www.heaithline.com/nutrition/Foods-high-in-phosphorus
34. Soetan KO, Olaiya CO, Oyewole OE. The importance of mineral elements for humans, domestic animals and plants: A review on some physicochemical properties of flour obtained from fermentation of tiger nut (*Cyperus esculentus*). Source from a market in Ogbomoso, Nigeria. African Journal of Food Science. 2010;3:51-55.
35. Wyn S. Minerals: Recommended intake levels; 2004. Available:www.supplementquality.com/news/
36. Office of Dietary Supplements (ODS). Dietary Supplements Fact Sheat: Iron Office of Dietary Supplements National Institutes for Health; 2007.
37. Organic Facts. 13 Incredible Benefits of Potassium; 2018. Available:http://www.organicfact.net/
38. Onimawo AI, Egbekun KM. Comprehension food science and nutrition. Ambik Press Benin; 1998.
39. Singh R, Gautan N, Misha A, Gupta R. Heavy metals and living: An overview. Indian J. Pharmacology. 2011;43(3):246-253.
40. Bastin. Minerals in the diet. Leader's Guide; 1996.
41. Farquar JN. Handbook of lipids in nutrition. CRC Press. Boca Raton, FL. 1996;101-105.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48397