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THE EFFECT OF PROCESSING METHODS ON THE NUTRITIONAL QUALITY OF AFRICAN BREADFRUITS (*TRECULIA AFRICANA*) SEEDS

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ABSTRACT: The extracted seeds of African breadfruit are identified to be extremely healthy whenever it is correctly processed. Therefore, the aim of the present study was to evaluate the effects of processing methods on the nutritional quality of African breadfruit seed. A qualitative phytochemical analysis including: Alkaloid, Flavonoid, Saponin, Tannin, Anthraquinone, Terpenoids, Steroid and Cardiac Glycosides for the different fraction of African breadfruit seed was performed using a standard method. The result revealed the presence and greater amount of phytochemical for the raw fraction; seven in eight, six in eight for steamed fraction, and four in eight for boiled and roasted respectively. Anti-nutrient, Proximate, and Mineral Content were also conducted using standard methods. The amino acid composition was determined using High-Performance Liquid Chromatography (HPLC). The results of the present study revealed that anti-nutrients including Phytate, Tannins, and Oxalate were significantly $p<0.05$ reduced in the boiled fraction 5.47±0.15, 3.42±0.02 and 6.89±0.05, and highest in the raw fraction 7.77±0.01, 5.09±0.03 and 9.34±0.14. The proximate composition including; percentage crude fat, Ash, Carbohydrate, Fatty acid, and Energy value were significantly lower $p<0.05$ in the boiled fraction relative to the other fractions. Mineral contents; calcium, magnesium, sodium, potassium, and phosphorus were also significantly $p<0.05$ elevated in the boiled fraction relative to the raw, steamed and roasted fraction. The amino acid composition was highest in the roasted and boiled fraction 57.350 and 56.978, and lowest in the steamed and raw fraction 35.754 and 28.748 respectively. Therefore, boiling (cooking) is encouraged for the preparation of African breadfruit seed.

Keywords: African Breadfruit, processing methods, amino acid composition, and mineral content

INTRODUCTION

There is growing awareness on the importance of legumes in diet, particularly its protein contribution (Obiakor and Nnadi, 2014). African breadfruit (*Treculia africana*), locally called Ukwa in Igbo and Afon in the Yoruba language, is regarded as an important leguminous food. The cooked seeds are valuable food particularly among the Igbos but also consumed by other Southern parts of Nigeria including; the Efiks, Kalabaris, Edos and the Ika Igbos in Delta State (Okonkwo and Ubani, 2007). The extracted seed of *T. africana* is reported to be extremely healthy whenever it is processed correctly (Nwaigwe and Adejumo, 2015; Okafor, 2008), and it is a very important indigenous fruit which plays a vital role in the diet of man (Obiakor and Nnadi, 2014).

African breadfruit (*T. africana*), is a tropical African leguminous crop of the family *Moraceae,* and genus *treculia*. In Africa, it is widely grown in the humid South Eastern ecological zone of Nigeria, and the humid rain forest of Southeast Cameroon (Nwaigwe and Adejumo, 2015). During processing, the seeds are extracted from the fruit heads after fermentation and used for the preparation of delicious and nutritious diets. Roasting, parboiling, dehulling, and steaming, are the processing methods or Pre-utilization treatments commonly used (Umezuruike et al., 2016). However, they are existing concerns about the effect of various process methods on nutrition content of foods, but the cumulative effect of processing on nutrients depends on the nature of the seed, processing method, duration of applied processing factors, environmental factors, presence of endogenous enzymes, and chemical composition (Umezuruike et al., 2016; Nwabueze et al., 2007; Fubara et al., 2011).

One of the prominent and the most encountered food processing treatments are either heat processing in the form of cooking, boiling or roasting, and of course, it improves various food components, quality, palatability and preservation (Umezuruike et al., 2016; Obiakor and Nnadi, 2014; Fubara et al., 2011). Despite this highlighted benefits of processing methods, they also confer some detrimental effects which oftentimes depend on the duration of cooking and high temperature, resulting in the loss of flavor and nutrients (Obiakor and Nnadi, 2014). Owing to this, it has become very necessary for heat processing methods to be carefully selected and controlled to avoid damage to nutritive value, functionality, and sensory properties which determine acceptability (Obiakor and Nnadi, 2014). Similarly, scientific evaluation of nutritional and other useful properties after processing is also considered very necessary (Arinola and Adesina, 2014).

Regardless of the already existing body of scientific evidence on the effect of various processing methods on the nutritional constituent of food, the general public tends towards choosing a processing method based on taste rather than on nutritional impact. Therefore, in an attempt to contribute to the growing body of knowledge on this subject, the study was conducted to evaluate the nutritional composition of raw breadfruit seed subjected to different processing methods (boiling roasting and steaming) respectively.

MATERIAL AND METHODS

Source and Preparation of African breadfruit

Fourteen mature fruit heads of African Breadfruit used for the present study were collected from a farm in Egbe-Ekiti, Ekiti State, Nigeria, and were identified by a botanist in the department of botany, University of Ibadan, Oyo State, Nigeria. Thereafter, the fruit heads of African Breadfruit were brought to the laboratory and kept in a sack, covered and left for 14 days to allow natural fermentation. After the fermentation has completed, the seeds were extracted and were thoroughly washed to remove all forms of debris and a slimy matrix. The washed seeds were then carefully selected to remove bad seeds and other extraneous materials.

Processing of Breadfruit

The African Breadfruit seeds were divided into four fractions weighting 200 grams each and labeled A, B, C, and D respectively. A represents a raw fraction, B represents a steamed fraction, C represents boiled fraction and D represents Roasted fraction. The raw fraction (A) was deshelled manually without any form of heat treatment, the steamed fraction (B) was steamed for 20 minutes at 100˚C and then deshelled, the boiled fraction (C) was parboiled for 10 minutes, deshelled and then cooked for 40 minutes at 100˚C, and the roasted fraction (D) was roasted in fine sand for a period of 25 minutes with continuous stirring, thereafter, allowed to cool and then deshelled. All samples were air-dried, grounded to a fine powder with the laboratory mill were necessary, and wrapped airtight bag until needed for analysis.

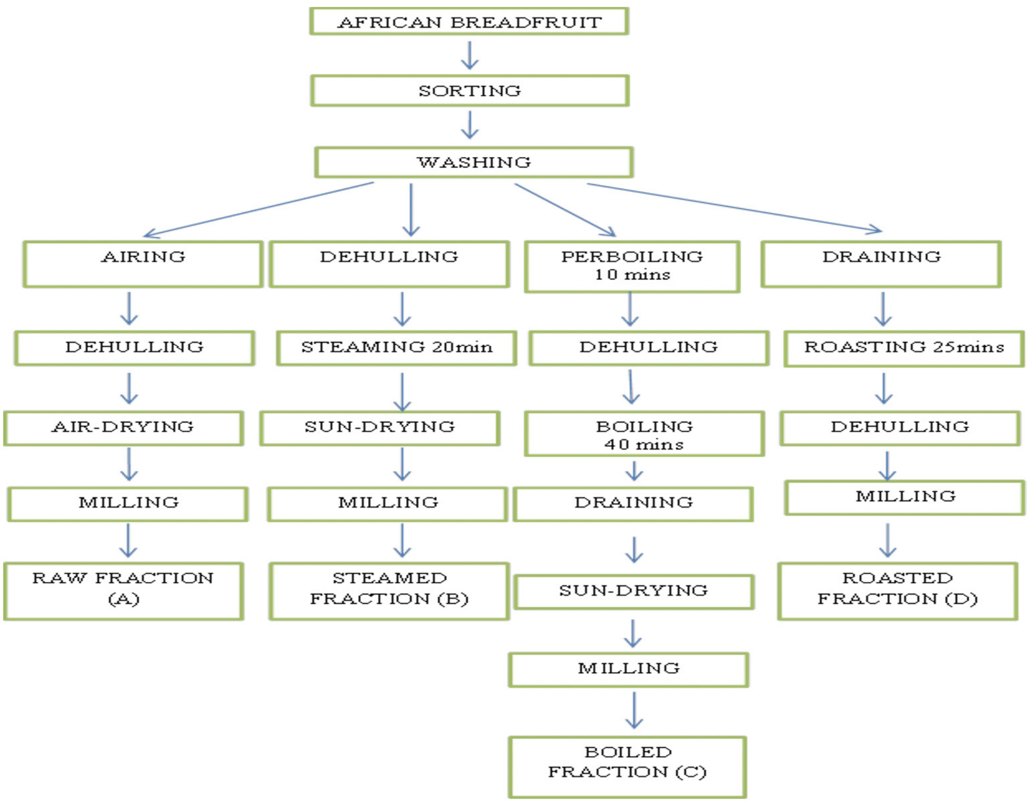

Figure 1. Flow chart of the processing methods used for the seeds

Proximate Analysis

The proximate parameters (moisture, ash, crude fat, crude fiber, and crude protein) contents were determined using the procedure described by AOAC (1990)). The carbohydrate content was determined by deducting the total percentage of moisture, ash, fiber, fat, and protein from 100. Calculated fatty acids (0.8 x crude fat) were estimated as described by (Tukura and Obliva, 2015), and Total energy was calculated using Atwater Factors: Energy value = % Protein x 4 + % Carbohydrate x 4+ % Fat x 9 as described by (Runsewe-Abiodun et al., 2018).

Mineral Analysis

The following Minerals; Sodium (Na), Potassium (K), Calcium (Ca), Iron (Fe), magnesium (Mg), Zinc (Zn), Copper (Cu) and Phosphorus (P) were determined using atomic absorption spectrophotometric methods according to AOAC (1995) as described by (Nwozo and Nwawuba, 2018).

Phytochemical Screening

Phytochemical analysis of African breadfruit seeds was conducted by standard methods as described by (Harbone, 1998; Allen et al., 1974).

Determination of Anti-nutrients Composition

Anti-nutrient compositions including; tannin, phytate and oxalate analysis of African breadfruit seed was conducted by standard methods as described by AOAC (2005).

Determination of Amino Acid Composition

The analysis of the Amino acids was done on waters 616/626 LC (HPLC) Instrument. 0.5g of the samples were weighed into sterile furnaces and then dried under a vacuum. The tube was again placed in a vial containing 10.05N HCl with a small quantity of phenol, thereby hydrolyzing the protein by the HCl vapors under vacuum. This stage of hydrolysis of the sample lasted for between 20 – 23 hours at 108^{o}C. After the hydrolysis, the samples were dissolved in ultra-pure water (HPLC) grade, containing ethylene diamine tetraacetic acid (EDTA). The hydrolyzed samples were derivalised automatically on the water 616/626 HPLC by reacting to the five amino acid, under basic situations with phenylisothiocyanate (PITC) to get phenylthiocarbamyl (PTC) amino acid derivatives. The duration for this is 45 minutes per sample, as calibrated on the instrument. After the derivatization, a methanol solution (1.5N) containing the PTC-amino acid was transferred to narrow bore water 616/626 HPLC system for separation. The separation and quantization of the PTC-aminoacids were done on a reverse phase and digitally detected at the wavelength of 254nm. The intensity of the chromatographic peaks areas was automatically and digitally identified and quantified using a Dionex chromeleon data analysis system which is attached to the waters 616/626 HPLC System. The calibration curve or file prepared from the average values of the retention times (in minutes) and areas (in Au) at the amino acids in 5 standard runs was used. Since a known amount of each amino acid in the standard was loaded into the HPLC, a response factor (Au/pmol) was calculated by the software that was interphased with the HPLC. This response factor was used to calculate the amount of each of the amino acid (in pmols) in the sample and displayed on the system digitally.

Calculation

Extract (mg/ml) = Dilution factor x Peak height intensity

$$\text{Sample (mg/ml)} = \frac{\mu\text{g/ml in extract x sample volume}}{\text{Wt. of sample}}$$

Statistical analysis

Data were treated by ANOVA (analysis of variance) and mean separation was done using Duncan multiple range test and Turkey. $p<0.05$ were considered significant. Data were expressed as means±standard deviation and pictorially presented in the form of charts. All statistical analysis was done using IBM SPSS Version 22 and Microsoft Excel.

RESULTS AND DISCUSSION

The ultimate goal of processing, however, is to preserve nutrients to make them available for consumers, and also to remove or reduce the levels of anti-nutritional factors which may interfere with nutrient digestion and absorption (Adesina and Adeyeye, 2015; Hassan et al., 2005). In light of this, the predominant and common food processing treatment in current use, is heat processing either by cooking, boiling or roasting (Obiakor and Nnadi, 2014). Therefore, the present study investigated the effect of heat processing by boiling, roasting and steaming on African breadfruit seeds, and the results revealed that the processing methods employed, resulted in a significant alteration in the nutritional contents of the seeds.

Phytochemical

Table 1 shows the effect of processing methods on the qualitative phytochemical constituent of African Breadfruit seed extracts. The investigation was carried out to assay for the presence of the following phytochemical constituent: Alkaloids, Flavonoids, Saponins, Tannins, Anthraquinones, Terpenoids, Steroids, and Cardiac Glycosides. African Breadfruit seed like any other legumes are known to contain some anti-nutrients, this includes; hydrogen cyanide, tannins, haemagglutinin, oxalate, alkaloids, lectins, saponins, and protease inhibitors (Nwaigwe and Adejumo, 2015). Thus, the result of the present study as demonstrated in (table 1) corroborates this finding, as there was a notable presence of alkaloids, saponin and tannin, and also some antioxidants in the raw fraction. However, the heat-processed fractions, particularly the boiled and the roasted, showed an absence of the anti-nutrient assayed for, but a presence of a considerable amount of antioxidant particularly flavonoid. The neutralization/detoxification of anti-nutrient in the processed fraction can, of course, be attributed to the processing methods employed, validating the reports that processing methods are beneficial and this is in harmony with the report of (Runsewe-Abiodun et al., 2018).

Table 1. Effect of processing methods on the phytochemical constituent of *African Breadfruit* seeds

Phytochemicals	Raw	Steamed	Boiled	Roasted
Alkaloids	++	+	+	+
Flavonoids	++	++	++	++
Saponins	++	+	-	-
Tannins	++	+	-	-
Anthraquinones	+	-	-	-
Terpenoids	++	+	+	+
Steroids	+	+	+	+
Cardiac Glycosides	-	-	-	-

(+) indicates the presence in trace amount, (++) indicates the presence in moderate amount, (+++) indicates the presence in strong amount, and (-) indicates not detected.

Anti-nutrient

To further support the beneficial role of processing methods on African breadfruits, the present study revealed the effect of processing methods on the levels of anti-nutrient including; Phytate, Tannins, and Oxalate in African breadfruit seed as demonstrated in figure 2. Previous study has shown that consumption of these anti-nutritive factors at high levels often results in toxicity and eventual death (Olivierira et al., 2015), and in the present study, as shown in figure 2, the levels of anti-nutrient was significantly higher $p<0.05$ in the raw fraction of African breadfruit seeds relative to the processed fractions. Therefore, to eliminate or reduce the effect of anti-nutrients, proper processing before consumption is very necessary (Muinat et al., 2009). In this light, of course, the present study revealed that the processing methods employed; steaming, roasting, and particularly boiling, significantly reduced $p<0.05$ the level of the anti-nutrients. Possibly, the reduction/elimination of anti-nutrient, in particular, tannin, could be attributed to the hydrolysis of the intermolecular forces that exist within the anti-nutrients (Omoikhoje et al., 2009).

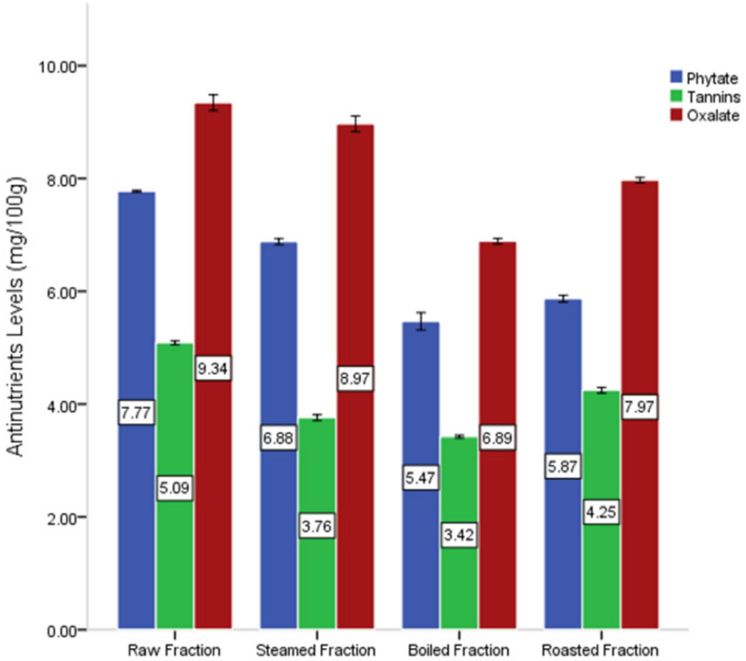

Figure 2. The effect of processing methods on African breadfruit seed anti-nutrient

Proximate

The effect of processing methods on African Breadfruit in the present study (Table 2) revealed that the processing methods employed caused a variation in the proximate composition of the seeds, as they were a significant $p<0.05$ difference in the raw fraction when compared to the processed fractions. However, this alteration in proximate composition inferred by the processing methods particularly the boiled fraction improved the nutritional status of the seeds. Notably, the boiled fraction contained the highest level of protein, fiber and the lowest levels of fat, carbohydrate, fatty acid and energy levels. Protein has been established as an essential component of diet needed for survival of animals and human being, their basic function in nutrition is to supply adequate amount of required amino acids (Okareh et al., 2015), intake of dietary fiber has the potential to protect against cardiovascular diseases, diabetes, obesity, colon cancer and other diverticular diseases (Runsewe-Abiodun, 2018), diets low in fat, fatty acid and energy content has been demonstrated to be a suitable dietary option for diabetes, obesity and related coronary heart disease (ADA, 2016). The result of the present study on the improved nutritional status of the boiled fraction of African breadfruit corresponds with the reports that the extracted seeds of African Breadfruit are identified to become extremely healthy whenever it is correctly processed (Nwaigwe and Adejumo, 2015; Okafor, 2008).

Mineral content

Legumes are considered to be an excellent source of dietary minerals such as phosphorus, potassium, magnesium, sodium, nitrogen, and calcium (Yasir and Asif, 2018). The consumption of these macronutrients greatly aids the body in building a strong immune system and generally improves nutritional and health status (Ilelaboye et al., 2013). However, some studies have revealed that processing methods lead to the leaching down of mineral contents in water during processing which results in the presence of low levels of the mineral content of the foods (Yasir and Asif, 2018; Ilelaboye et al., 2013). In contrast, the result of the present study as shown in figure 3, revealed that processed fractions particularly the boiled fraction, contained a greater amount of the assayed minerals relative to the raw fraction. The possible explanation of the present result may be attributed to either the processing method or the time duration for processing. In correspondence to time duration, been a reason for the increased levels of mineral content in the processed fractions, the study of Omoikhoje et al., 2009 on the effect of cooking time on Bambara groundnut seeds, reported that; amongst the mineral

Table 2. The effect of processing methods on the proximate composition of African Breadfruits

Proximate	Raw	Steamed	Boiled	Roasted
% Crude Fat	3.20±0.02[a]	3.50±0.30[a]	3.23±0.25[a]	5.15±0.55[b]
% Crude Fibre	6.63±0.25[c]	4.51±0.11[a]	5.50±0.03[b]	4.63±0.21[a]
% Crude Protein	17.33+0.49[c]	9.68±0.65[a]	20.01±0.51[d]	13.80±0.69[b]
% ASH	2.15±0.09[c]	1.77±0.05[b]	1.51±0.01[a]	2.34±0.12[c]
% Moisture	8.83±0.11[a]	10.23±0.25[b]	12.45±0.05[c]	9.73±0.03[b]
% Carbohydrate	61.85±0.50[b]	70.31±0.99[d]	57.30±0.55[a]	64.35±0.67[c]
Fatty Acid	2.56±0.16[a]	2.80±0.24[a]	2.59±0.20[a]	4.12±0.44[b]
Energy Value (Kcal)	345.52±2.08[b]	351.45±1.70[b]	338.31±2.10[a]	358.91±3.55[c]

n=3. Data are expressed as means±SD: Mean values in the same column with different superscripts are significantly different at $p < 0.05$.

elements assayed for, calcium, magnesium, and iron were significantly ($P < 0.05$) increased with increased cooking time. However, a further study will be conducted to re-evaluate the processing method and evaluate the effect of cooking time on the mineral content of African breadfruit seed, to validate the present result.

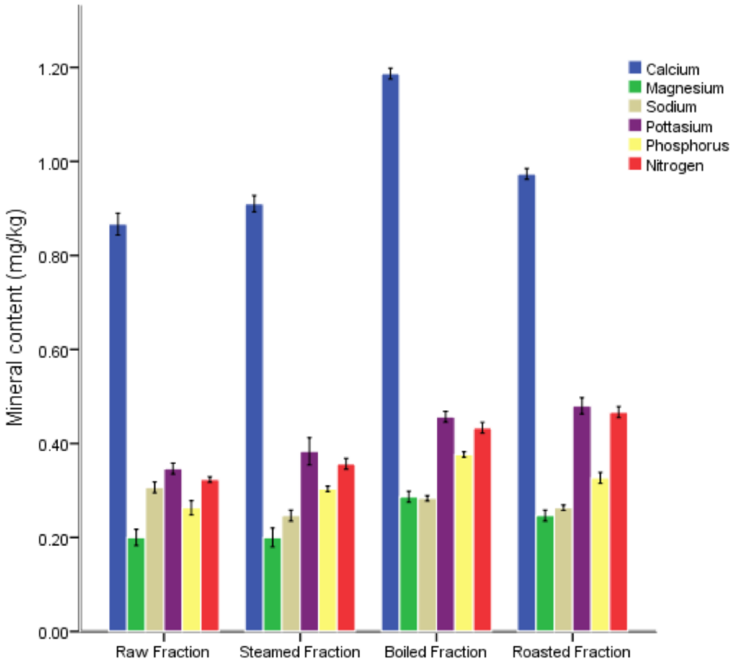

Figure 3. The effect of processing methods on the mineral content of African breadfruit

Amino acid composition

The quality of protein depends on its amino acid content (Ismail & Hainida, 2004). The present study identified the presence of twenty amino acids including: Threonine, Leucine, Isoleucine, Lysine, Methionine, Phenylalanine, Tyrosine, Valine, Arginine, Histidine, Alanine, Aspartic acid, Asparagine, Glutamic acid, Glutamine, Glycine, Proline, Serine, Tryptophan, and Cysteine. Each of these amino acids varied considerably between the processing methods employed in the current study; boiling, steaming, roasting and the raw fraction respectively. Total amino acid was estimated from the sum of all amino acid present, and the result of this study (table 3) indicated that the roasted and boiled fraction had higher amount of total amino acid with value (57.350 and 56.978) mg/100g, whereas the raw and the steamed fraction had the least total amount of amino acid with the value (28.748 and 35.754) mg/100g. This report is consistent with the finding of (Adeyeye and Adesina, 2013), which also reported a considerable improvement of protein (amino acids) level of raw African breadfruit by boiling and roasting. The increased levels in the total amount of amino acid, which translates to protein, may be attributed to the fact that heat processing in the form of cooking, prevents the formation of complex linkages of anti-nutrients with protein, thereby resulting to increased protein availability (Omoikhoje et al., 2009). Additionally, a study has revealed that anti-nutrient reduces protein absorption of foods due to its chelating ability (Müge et al., 2018). Therefore, anti-nutrient and protein (amino acid) have an inverse relationship. That is, the lower the level of anti-nutrient, the higher the level of protein (amino acid) and vice versa. Thus, the anti-nutrient level of African breadfruit seed in this study was of course reduced by cooking.

Table 3. The effect of processing methods on the amino acid composition

S/NO	Sample particulars (mg/100g)	Raw	Steamed	Boiled	Roasted
1	Threonine	3.877	2.493	5.187	4.173
2	Leucine	0.598	1.801	1.169	1.083
3	Isoleucine	0.500	0.212	0.669	2.457
4	Lysine	0.086	0.075	4.319	4.162
5	Methionine	6.818	8.182	10.817	9.107
6	Phenylalanine	5.781	0.868	0.016	0.012
7	Tyrosine	4.798	2.978	7.876	5.113
8	Valine	3.957	0.995	4.534	3.428
9	Arginine	0.655	0.287	0.220	0.114
10	Histidine	0.721	0.138	1.339	2.118
11	Alanine	0.075	0.086	0.672	1.008
12	Aspartic acid	1.156	1.181	0.295	0.233
13	Asparagine	0.031	0.028	0.058	0.059
14	Glutamic acid	9.959	4.049	9.545	9.091
15	Glutamine	0.681	2.240	3.180	6.359
16	Glycine	0.043	0.140	1.953	2.957
17	Proline	0.546	1.102	4.277	5.032
18	Serine	0.400	0.405	0.626	0.626
19	Tryptophan	3.141	1.156	1.151	0.145
20	Cysteine	0.932	0.332	0.074	0.074
	Total Amino Acids	35.754	28.748	56.978	57.350

CONCLUSION

The value of any food is in its nutritional content and employing a suitable cooking method, ensures that the nutritional advantage of the food is maintained. The results of the present study revealed that boiling is a suitable processing method for the preparation of African breadfruit seeds. The boiled fraction had the lowest level of anti-nutrient, increased level of medicinal advantageous proximate composition, improved mineral content and enhanced level of amino acid composition. Therefore, boiling (cooking) is encouraged for the preparation of the African breadfruit.

Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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