

Dietary Fibre and Fatty Acid Evaluation of Boiled, Roasted, Germinated and Fermented Breadnut (*Ukwa bekee*) Seed Flours

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Abstract: Evaluation of dietary fiber and fatty acid composition of boiled, roasted, fermented and germinated breadnut seed flour was investigated. The seeds were dehulled and washed. It was divided into four equal parts for different processing techniques: boiled, roasted, germinated and fermented. They were analyzed for dietary fibre and fatty acid composition using standard methods. Data were subjected to statistical analysis using Statistical Product for Service Solution (SPSS) version 23.0. Values were expressed as means and standard deviation, Duncan multiple range test was used in separating the means at 95% confidence interval. Dietary fibre composition showed that breadnut seed flours range from 4.94% (fermented breadnut seed flour) to 5.42% (roasted breadnut seed flour). Fatty acid profile showed that breadnut seed flours contain a greater amount of non-essential fatty acids which were highly significant ($p < 0.05$) in oleic acid (57.93%) for roasted breadnut seed flour followed by linoleic acid (25.76%) in fermented breadnut flour. Stearic acid was the only prominent non-essential fatty acid in the breadnut seed flour and ranged from 4.40% (fermented breadnut seed flour) to 6.27% (germinated breadnut seed flour). The study revealed that all the processed breadnut seed flours have appreciable quantities of dietary fibre and essential fatty acids than non-essential fatty acids. Breadnut seed should be recommended in wheat substitution in bakery industry and culinary uses. It is also recommended for weight loss program.

Key words: Breadnut, fermentation, boiling, roasting, germination.

1. Introduction

Breadnuts (*Artocarpus camansi*) otherwise known as breadnut seeds constitute a very important diet in Nigeria [1]. Breadnut (BN) is a seeded breadfruit which is primarily grown for its nutritious seeds which vary in their seed number and sizes. The nuts are usually consumed when immature, thinly sliced and boiled as a vegetable in soups or stews and are regarded as the poor man's substitute for yam because it is cheap and so, used in several traditional food preparations in lieu of yam. Adeleke and Abiodun [2] stated that breadnut serves as a good source of protein and it is low in fat content compared to other nuts such as almond and Brazil nut.

Breadnut (*Artocarpus camansi*) belongs to the mulberry family Moraceae which is considered to be seeded specie of breadfruit and it is primarily grown for its nutritious seeds [2]. Breadnut (*Artocarpus camansi*) is a less known and under-exploited crop, it is said to have originated to the New Guinea and Moluccia; and have a very restricted range of cultivation being confined to tropical Africa, particularly Nigeria where it is grown at subsistence level [3]. Further, it is cultivated in both high rainfall and savanna area of Nigeria. It is grown successfully in areas with annual rainfall of between 500-600 mm. It grows satisfactorily on many types of soil and most types of tropical and subtropical climate [4].

Breadnut is frequently mistaken with breadfruit but can be distinguished by their physical characteristics and even taste in most cases [5]. The fruit and nut

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have been neglected, underutilized and underdeveloped in most cases as its utilization has been limited to vegetable stew and boiled seed only by the Philippines. In Nigeria, breadnut is consumed only as boiled food crop. The uses of breadnut are that the matured seeds are boiled in salted water together with the shell and underlying membrane. Boiled or roasted breadnut seeds are delicious with a flavour resembling that of a chest nut. Immature breadnuts are thinly sliced and boiled as a vegetable in soups or stew [6].

However, breadnut has a shelf life of 2-3 days after they are ripe and deteriorate rapidly. Its highly perishable nature results to apparent rotten fruit during its season in the garden and in the market [7, 8]. Breadnut needs to be processed to avoid spoilage and wastage during the season. It can be preserved by different ways of processing (boiling, roasting, germination and fermentation). These processes add to the nutritive value of food and as well as the flavour and other desirable qualities associated with digestibility and edibility [9].

Nigeria is adorned with a wide range of indigenous fruits and food. Despite the nutritive value of breadnut seed, it had been reported to be an underutilized food [10]. Breadnuts which have been boiled (subjected breadnut to heat of boiling in liquid), roasted (breadnut prepared by prolonged exposure to heat over a fire), fermented (processes of breaking down of sugar content in a food in the absence of oxygen) and germinated (natural process in which high dormant but viable breadnut seeds are induced to start growing into seedlings) are evaluated for their nutrient especially for their fatty acid and dietary fiber content.

Although, various researches have been carried out on the nutrient composition and usefulness of breadnut as a food [11] but no work has been done on the dietary fibre and fatty acid evaluation of boiled, roasted, germinated and fermented breadnut. This present work will focus on the evaluation of dietary fibre and fatty acid in boiled, roasted, fermented and germinated breadnut seeds.

Breadnuts are underutilized and neglected [12, 13] but their importance cannot be overemphasized. Their underutilization is partly due to social stigmatization, both in Nigeria and other parts of the world, as food for slaves and the poor. They are generally considered as unimportant food crops. These have therefore led to their neglect [10]. Although breadnuts have been neglected, they have untapped potential which needs to be harnessed [14, 15]. The World Food Program encourages the incorporation of highly nutritious but neglected foods in the diets as a means of combating malnutrition [16]. Further, the nutritive value of breadnut is high and can be a source of some nutrients especially minerals and protein which can help in the reduction of some nutrient deficiency diseases [17]. To this end, research into breadnuts seeds as dietary component has recently gained attention. Nelson-Quartey et al. [18] produced infant formulations from *A. altilis* and *A. camansi* flours while Oduro et al. [19] produced a breakfast meal from *A. altilis* pulp flour. Roberts et al. [20], reported on the potential of breadnuts for production of fried chips. Most studies conducted, treated the properties of breadfruit on an ad hoc basis, without considering differences due to cultivars [21]. Enibe [14] as well as Beyer [15] indicated that breadnuts have the potential to contribute to food security and need to be better utilized through food processing techniques such as boiling, roasting, germination and fermentation, which could be achieved by having information on the nutritional composition. Similarly, Baccus-Taylor and Akingbala [21] have emphasized the need for research into available species of breadnuts, their nutrient and functional properties among others for food and industrial use to fill the knowledge gap. This study therefore is aimed to evaluate the dietary and fatty acid composition of boiled, roasted, germinated and fermented breadnut seed flours. Information on these would increase utilization of breadnut seeds, improve nutrition, enhance food security and assist in commercializing breadnuts as a source of income.

2. Material and Methods

2.1 Sample Procurement

The sample of matured breadnut fruit (*Artocarpus camansi*) was obtained from Eke-Iho market in Ikeduru Local Government Area, Imo State. It was identified by the Crop Science Department in Imo State University, Nigeria.

2.2 Processing of Material

2.2.1 Processing of Roasted Breadnut

Breadnut seeds were removed from the shell and sliced into pieces with knife, it was roasted in an oven at 500 °C for about 40 minutes, milled and sieved using 300 m sieve to obtain breadnut flour of uniform sizes.

2.2.2 Processing of Germinated Breadnut

Breadnut seeds were removed and allowed to

germinate at room temperature for 4 days. The germinated seeds were sliced into pieces with a sterile knife, sundried, milled and sieved using 300 m sieve to obtain breadnut flour of uniform sizes.

2.2.3 Processing of Boiled Breadnut

Breadnut seeds were removed and sliced into pieces with knife; it was boiled for about 45 minutes, sundried, milled and sieved using 300 m sieve to obtain breadnut flour of uniform sizes.

2.2.4 Processing of Fermented Breadnut

Breadnut seeds were removed and sliced into pieces with knife; it was boiled for about 45 minutes. The fermented seed were obtained by adding 3:1 ratio of water to 600 g boiled breadnut seed and was allowed to ferment naturally at room temperate for 48 hours, sundried, milled and sieved using 300 m sieve to obtain breadnut flour of uniform sizes.

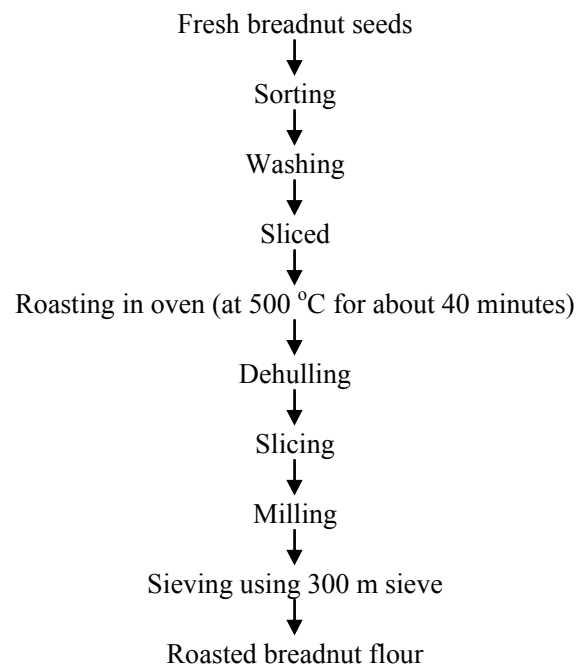


Fig. 1 Flowchart of roasted breadnut seed flour.

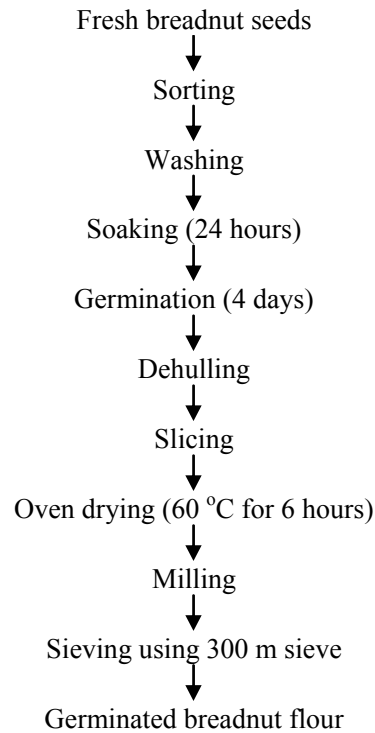


Fig. 2 Flowchart of germinated breadnut seed flour.

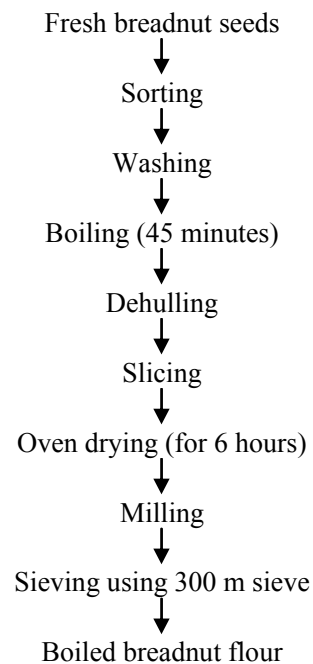


Fig. 3 Flowchart of boiled breadnut seed flour.

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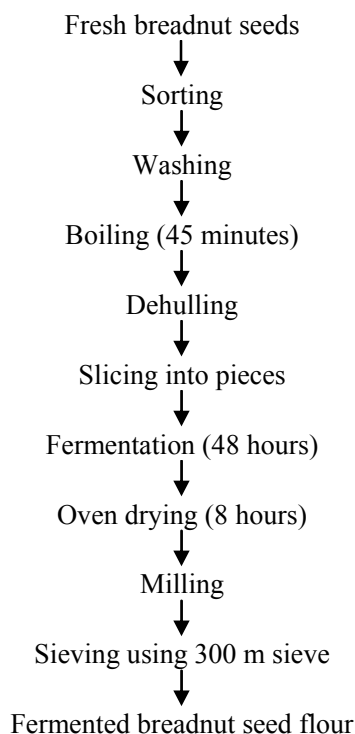


Fig. 4 Flowchart of fermented breadnut seed flour.

2.3 Determination of Dietary Fiber

Dietary fiber content in any sample is measured in the laboratory by what is referred to as an enzymatic gravimetric method described by Prosky et al. [23]. After defatting, the food sample was treated with enzymes that mimic the digestive process in the human small intestine.

Protein was digested by protease while digestible carbohydrates are broken down into simple sugars and removed from the sample by precipitation and filtration. This mimics absorption of these sugars in the body. The non-digestible precipitate contains the dietary fiber but also contains protein remnants and inorganic material. These should not be included in dietary fiber so protein and inorganic material must be measured and subtracted from the weight.

2.3.1 Analysis of Fatty Acids

AOAC official methods [22]: fat and fatty acids were extracted from food by hydrolytic method. Fat was extracted into ether, and then methylated to fatty

acid methyl esters (FAMES). FAMES were quantitatively measured by gas chromatography.

Hydrolysis. Weigh sample and pyrogalllic acid into the Mojonnier flask. Add internal standard, ethanol and 8.3 M HCl. Hydrolyze the sample at 70-80 °C. Remove flasks from water bath. Cool to room temperature.

Extraction. Add ethanol, ether and shake. Centrifuge sample. Decant the ether layer into a tube. Evaporate ether on water bath using nitrogen stream to aid in evaporation. Dissolve the residue in chloroform.

Methylation. Transfer mixture to a glass vial. Evaporate to dryness. Add 7% BF₃ reagent and toluene. Seal vials with screw cap and heat them at 100 °C. Allow vials to cool to room temperature. Add water (5 mL), hexane (1 mL), Na₂SO₄ (1 g). Shake to allow layers to separate and transfer top layer to another vial containing Na₂SO₄ (1 g).

Top layer should contain FAMES and internal standard. Then transfer to autosampler vial for gas chromatography (GC) analysis.

2.4 Statistical Analysis

Data were analyzed using statistical products and services solution (SPSS) version 23.0 for mean and standard deviation. Analysis of variance (ANOVA) was used to compare the means, Duncan multiple range test was used to separate the means at $p < 0.05$ significance.

3. Results

Table 1 shows the dietary fibre composition of roasted, germinated, boiled and fermented breadnut flour. There were significant differences ($p > 0.05$) in the dietary fibre composition of the processed breadnut seeds. The fibre composition of the samples ranged from 4.94 ± 0.05 g (fermented breadnut flour) to 5.42 ± 0.03 g (roasted breadnut flour).

The fatty acid composition of the four different processed breadnut flours was presented in Table 2 below. There was no significant difference ($p > 0.05$) in the essential fatty acids though it was higher in fermented breadnut seed flour for oleic ($57.93 \pm 0.001\%$) > linoleic acid (25.76 ± 0.001) > arachidonic acid ($0.77 \pm 0.63\%$), boiled breadnut seed flour was higher in erucic acid ($0.59 \pm 0.01\%$) > linolenic acid ($0.32 \pm 0.00\%$) while roasted breadnut was higher in arachidic acid ($0.63 \pm 0.01\%$). Prominent non-essential fatty acids were observed to be higher in boiled breadnut seed flour for palmitic acid ($0.63 \pm 0.09\%$) > lignoceric acid ($0.32 \pm 0.01\%$) > megaric acid ($0.09 \pm 0.01\%$), germinated breadnut seed flour was higher in stearic acid ($6.27 \pm 0.01\%$) > behenic acid ($0.42 \pm 0.00\%$) while myristic acid was higher in roasted breadnut seed flour (0.28 ± 0.01).

Table 1 Dietary fibre composition of roasted germinated, boiled and fermented breadnut seed flours.

Breadnut	Dietary fibre (g)
Roasted	$5.42^a \pm 0.03$
Germinated	$5.05^c \pm 0.14$
Boiled	$5.25^b \pm 0.11$
Fermented	$4.94^d \pm 0.05$

Values are means \pm standard deviation of duplicate determination. Means with the same superscript within the column are not significantly different ($p > 0.05$) while different superscripts within the column are significantly different ($p < 0.05$).

Table 2 Fatty acids profile of boiled, roasted, germinated and fermented breadnut seed flours.

Fatty acids	Germinated	Fermented	Roasted	Boiled
Essential	Fatty acids	/unsaturated	Fatty	Acids
Oleic acid (%)	$53.48^a \pm 0.01$	$57.93^a \pm 0.01$	$57.09^a \pm 3.53$	$54.61^a \pm 2.82$
Linoleic acid (%)	$23.91^a \pm 0.01$	$25.76^a \pm 0.01$	$24.27^a \pm 0.01$	$24.92^a \pm 0.00$
Linolenic acid (%)	$0.17^a \pm 0.00$	$0.18^a \pm 0.01$	$0.17^a \pm 0.01$	$0.32^b \pm 0.00$
Arachidic acid (%)	$0.58^b \pm 0.01$	$0.18^a \pm 0.01$	$0.63^b \pm 0.01$	$0.25^a \pm 0.09$
Arachidonic acid (%)	$0.07^a \pm 0.00$	$0.77^b \pm 0.63$	$0.07^a \pm 0.01$	$0.14^a \pm 0.01$
Erucic acid (%)	$0.31^a \pm 0.01$	$0.31^a \pm 0.01$	$0.32^a \pm 0.01$	$0.59^b \pm 0.01$
Non-essential	Fatty acids	/saturated	Fatty	Acids
Myristic acid (%)	$0.27^a \pm 0.01$	$0.13^a \pm 0.01$	$0.28^a \pm 0.01$	$0.25^a \pm 0.01$
Palmitoleic acid (%)	$0.33^a \pm 0.01$	$0.33^a \pm 0.01$	$0.35^a \pm 0.01$	$0.63^b \pm 0.09$
Margaric acid (%)	$0.04^a \pm 0.01$	$0.05^a \pm 0.01$	$0.05^a \pm 0.63$	$0.09^a \pm 0.01$
Stearic acid (%)	$6.27^b \pm 0.01$	$5.40^b \pm 0.01$	$4.44^a \pm 0.01$	$5.26^b \pm 0.01$
Behenic acid (%)	$0.42^a \pm 0.00$	$0.34^a \pm 0.43$	$0.21^a \pm 0.01$	$0.38^a \pm 0.01$
Lignoceric acid (%)	$0.20^a \pm 0.01$	$0.11^a \pm 0.01$	$0.02^a \pm 0.01$	$0.32^a \pm 0.01$

Values are means \pm standard deviation of duplicate determination. Means with the same superscript within the column are not significantly different ($p > 0.05$) while different superscripts within the column are significantly different ($p < 0.05$).

4. Discussion

Dietary fibre content of the processed breadnut seed flours was higher than the report by Oladele and Oshodi [24] in breadnut which was 2.75% but lower than the dietary fibre content of 4.9% on raw breadnut seed reported by Echendu et al. [25]. The dietary fibre content in the roasted breadnut flour had the highest value while fermented breadnut flour had the lowest amount of dietary fibre. The high dietary fibre content of the roasted breadnut seed flour was consistent with the result of Azizah et al. [26] who attributed the increased dietary fibre content to effect of Millard reaction which may be analysed as lignin and thereby increase the apparent fibre content of the flour. Azizah et al. [26] also had consistent results that showed increase in dietary fibre of breadfruit due to boiling. The result suggested that subjecting starchy food to heat may confer more ordered structures to the starch molecules and render some of the starch indigestible, since they are not digestible, and they are classed under dietary fibre [26].

Benitez et al. [27] also reported increase in total dietary fibre content of legumes during germination which was attributed to series of metabolic reactions during germination. Fermented breadnut flour had the lowest dietary fibre content when compared to the other processed flours. The reduction may be attributed to the ability of the fermenting micro flora to hydrolyse and metabolize them as a carbon source (substrate) in order to synthesize cell biomass. This was in agreement with Oladumoye [28]. Dietary fibre is the sum of lignin and polysaccharides that are not digested by endogenous secretions of the human digestive tract [29]. It is an important component of food. High fibre content helps prevent or alleviate maladies such as cardiovascular disease, diabetes, diverticulitis and colon cancer [30].

Monounsaturated and polyunsaturated fatty acids are higher in the breadnut seed flours than saturated fats making the fat present in the flours a healthy

source. Linoleic acid also called omega-6-fatty acid is one of the most important essential fatty acids that are required for growth, physiological functions and general body maintenance [31].

The prominent fatty acids components in the four breadnut seed flours were two essential fatty acids (oleic and linoleic) followed by two non-essential fatty acids (palmitic and stearic acids). This observation was similar with Adeleke and Abiodun [2] on fatty acids composition of breadnut though they reported higher values for palmitic acid (21.4%) but lower values for linoleic (14.8%), oleic (12.4%) and stearic (2.0%) when compared with the results of the present study. The increase in the fatty acid value of the present study may be as a result of the processing methods (boiling, roasting, fermentation and germination) used. Both oleic and linoleic acids work together to regulate blood clotting, immune response and inflammatory process and decrease LDL-cholesterol concentration which reduces cardiovascular disease risk. Deficiency of these essential fatty acids leads to dry hair, hair loss and poor wound formation. The observation that linoleic acids (essential fatty acids) are the principal fatty acids in the breadnut flour was consistent with the report of Grosso et al. [32] who stated that linoleic fatty acids are the major essential fatty acids in plant seeds such as peanut, lentils and soybeans.

The oleic acid content of the breadnut was higher than that reported for African locust bean (32.24%) [33]. Roasted breadnut seed flour was observed to have highest values for palmitic and stearic acids which are both saturated fatty acids. This was inconsistent with the report of Hadeel et al. [34] who reported that roasting increases the monounsaturated contents of nuts and seed oil.

It was observed that fermentation yielded high linoleic (polyunsaturated fatty acids). On the contrary, Audu et al. [35] reported that fermentation did not have much effect on the fatty acid composition but however increased the total unsaturated fatty acids.

Abdulbasit et al. [36] reported that roasting and boiling of safflower seeds had no effect on the fatty acids composition of safflower. However, fermented breadnut flour had the highest oleic and linoleic fatty acids which are the principal unsaturated fatty acids in the processed breadnut flour. The values for oleic acid in this study were higher than that of melon seeds. This study suggests that the four processed flours are good sources of essential fatty acids and contain edible and healthy oil for human consumption.

Essential fatty acids are polyunsaturated fatty acids. The body cannot produce them and therefore they need to be consumed in foods. They include the linoleic (the omega-6-fatty acids) and the linolenic (omega-3-fatty acids). Comparing the results of this study for the essential fatty acids (linoleic and linolenic) in the four processed breadnut flours with the recommended daily allowance by the World Health Organisation and the Food and Nutrition Board of the US Institute of Medicine, it was observed that 100 grams of the processed (germinated, boiled, fermented and roasted) flours will by far meet the recommended daily allowance (RDA) for linoleic acid for infants, toddlers, school children, adolescents and adults male and female. However, the linolenic fatty acid content in the four processed breadnut flours was lower than the recommended daily requirements by the World Health Organization and the Food and Nutrition Board of the US Institute of Medicine. Clinical signs for deficiency of essential fatty acids are decreased growth in infants and children, dry scaly rash, susceptibility to infection and poor wound healing.

5. Conclusion

The result obtained in this present study showed that the major fatty acids concentration consisted of unsaturated fatty acids; monounsaturated and polyunsaturated fatty acids which were evenly distributed in the four flours. The flours were also found to be rich in essential fatty acids and could

provide greatly to the RDA of humans.

The study revealed that the flours have high nutritional values that can be exploited and considered as an alternative source of nutrients to reduce malnutrition among economically weaker categories of people in developing countries. The use of these flours as food could help provide needed energy, essential fats and help combat malnutrition.

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