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Research Article

Production and Nutritional Evaluation of African Breadfruit Yoghurt

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Abstract

African breadfruit milk was combined with a commercial yoghurt starter culture (a blend of Lactobacillus bulgaricus and Streptococcus thermophilus) to create both fresh and dried African breadfruit yoghurt. The yogurt and milk samples were assessed for their nutritional value. Breadfruit seed milk samples had the following approximate compositions (%): MFABS and MDABS had 14.64, 28.34 of carbohydrates; protein (3.07, 3.19); fat (1.56, 2.61); fiber (0.92, 1.34); ash (1.68, 0.92); moisture (78.23, 63.59); and energy (351.39, 632.58) kJ/100g, respectively. The following are the micronutrient compositions (mg/100g) of breadfruit milk samples: Phosphorus (41.36, 43.81), calcium (38.53, 39.56), zinc (0.74, 1.81), iron (4.81, 5.94), and vitamin C (0.75, 0.50) were found in MFABS and MDABS, in that order. The following are the micronutrient compositions (mg/100g) of breadfruit yoghurt samples: Phosphorus (39.27, 41.31, and 48.47), calcium (35.71, 36.32, and 49.81), zinc (0.70, 0.72, and 1.27), iron (1.76, 1.80, and 2.32) and vitamin C (0.62, 0.53, and 0.56) were found in YFABS, YDABS, and CY, in that order. The nutritional compositions of African breadfruit seed milk and yoghurt samples differed significantly ($P \leq 0.05$). Therefore, African breadfruit seeds could effectively function as a substitute vegetable substrate for yoghurt, increasing its use in food production.

Keywords: Milk, Yoghurt, Vitamin C, Proteins, Energy Values, Phosphorus, Calcium and Zinc.

1. Introduction

Milk is an excellent supplier of all nutrients, except for iron and ascorbate. It has long been understood that breast milk is an essential food for infants and young children. The scarcity of milk in underdeveloped countries may have led to the development of alternative milk derived from vegetable sources [1]. But before the invention of vegetable milks like soymilk, which serve as a less expensive substitute for dairy milk, direct milk intake as a beverage was unusual in Nigeria. A different method of creating a wholesome meal based on vegetables is the creation of milk substitutes produced from legumes. For ethical (as with vegans) or medical (as with milk allergies and galactosemia) reasons, infants in communities where dairy milk is not provided can drink vegetable milks [2, 3]. The food business has enormous growth potential when it comes to non-dairy probiotic products, which might be further investigated through the creation of novel ingredients, procedures, and goods. Traditional nondairy fermented drinks come in a huge range of varieties, produced all over the world. A large portion of them are non-alcoholic drinks made primarily from grains [4]. However, probiotic-containing fruit juices, sweets, and legume-based goods can also be employed [5]. There has been a lot of interest in the use of lactic acid bacteria to prepare plant-based milk fermentation [2]. Breadfruit milk fermentation by LAB has received no attention [3].

Vegetable milk production is becoming more popular as a result of consumers' growing awareness of the nutritional advantages of plant-based foods, health-conscious lifestyles,

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vegetarianism, and diets devoid of cholesterol, lactose, and dairy [4]. Vegetable milk and its protein isolate beverage have received a lot of interest since they are wholesome and nutrient-dense [6]. As a result, a range of milk-based products, such as coffee creamers and chocolate milk drinks, have incorporated soybeans and peanuts [6]. Because of the properties of legumes and oil seeds, it is convenient to combine two or more to produce a satisfactory product [6]. The main disadvantages of fermented dairy products include lactose intolerance, milk allergies, cholesterol content, and an increase in vegetarianism among consumers [7]. The use of probiotic organisms is currently restricted to dairy products, particularly yoghurt, which may contain lactose residue even after fermentation [7]. Since only a wealthy minority in developing nations can afford these products, it is necessary to develop probiotic products derived from plants. A range of raw ingredients, particularly breadfruit, which doesn't contain lactose, can be used to make the non-dairy probiotic drinks [1].

A culture of bacteria that forms acids is added to milk after it has been homogenized, pasteurized, and fermented to create yoghurt. It's a nutritious food that's beneficial for both young children and the elderly. Yogurt is a well-balanced source of protein, fats, carbohydrates, and minerals for kids. For senior citizens who usually have more sensitive colons and whose intestines have run out of lactase, yoghurt is also a valuable food. Deteriorating bifidum levels in the intestines of the elderly may be due to the growth of bacteria that produce toxins and possibly cause cancer. Yogurt may lower the risk of high blood pressure and help prevent osteoporosis. It is made by fermenting milk with lactic acid using a starter culture that contains *Lactobacillus dellbruekii sub-spp. bulgaricus* and *Streptococcus thermophilus*. According to Sierra *et al*., these two genera' contributions to the production of yoghurt can be summed up as the acidification of milk and the synthesis of aromatic compounds [8].

Utilizing breadfruits and breadfruit products has been the focus of efforts to produce edible food items. Tertulia, a wild tropical evergreen tree, produces African breadfruit, which has enormous potential for use by humans as food [9]. African breadfruit is a source of protein, fat, vitamin, mineral, and other nutrients, just like most grain legumes grown in Africa. It is a good source of energy because it is also high in carbohydrates. African breadfruit, according to Ejidike and Ailey, is low in sodium, iron, and copper but rich in several minerals, including calcium, magnesium, and potassium [10]. Because of their low inherent levels, they must therefore be fortified with sodium, iron, and copper when used in food formulations. The seed has 17–23% crude protein, 11% crude fat, and other important vitamins and minerals, according to proximate analysis [11]. African breadfruit seeds have a total lipid content of 4-7% and less fat than some other nuts. As such, it is advised as a component of a diet to lose weight. The seeds are poor in dietary fiber and low in crude fiber, both of which are necessary for lowering cholesterol levels in the body and lowering the risk of cardiovascular diseases brought on by elevated plasma cholesterol. It's a good source of vitamin C as well.

Soy beans are one of the plant milk sources that have drawn the most research attention; further studies are being conducted to enhance the quality of soy milk [12]. As sources of plant milk, peanuts and Bambara groundnuts have received comparatively less research attention [1, 13]. People with lactose intolerance or cow's milk allergies can eat yoghurt made from dried, dehulled breadfruit milk seeds, as can children and expectant mothers. Additional factors include personal taste preferences, ovo-vegetarianism and veganism, as well as medical conditions like PKU, a rare genetic disorder that necessitates a low-phenylalanine diet and makes it difficult or impossible to digest animal proteins, particularly casein found in dairy products.

The overall goal of this project is to use breadfruit milk—made from both wet and dry breadfruit seeds—to make yoghurt. The study's specific goals are to make yoghurt from breadfruit milk and ascertain the nutritional makeup of the yoghurt samples. Undoubtedly, breadfruit exhibits significant potential as a crop. Due to its potential to improve food scarcity and the ability of both rural and urban residents to earn an income, breadfruit has recently drawn increased attention from both researchers and farmers. All that's needed is a stronger push to promote the growth of breadfruit seed-derived food products' production and consumption.

2. Materials and Methods

Source of Materials: Breadfruit, or Treculia africana, mature fruit heads were obtained from Olokoro in Umuahia South Local Government Area, Abia State. The sugar, skim milk, and yogurt starter culture were purchased from the Umuahia main market in the Nigerian state of Abia. The analytic grade regents were employed.

Experimental Site

The breadfruit seeds were cleaned and dehulled in Olokoro, Umuahia, South LGA, and Abia State. In the Food Processing and Analytical Laboratory of the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, the extraction of breadfruit milk, the making of yoghurt, and an analysis of the nutritional value of the yoghurt and breadfruit seed milk were conducted.

Preparation of Breadfruit Seed Meal

The pulp of the fermented breadfruit heads was used to extract the breadfruit seeds. Sand from the stream was used as an abrasive to wash the extracted seeds and get rid of the pulp that stuck to them. A-5 kg of breadfruit seeds were cleaned, then parboiled for 13 minutes at 80 oC to remove the seeds' hulls (Figure 1). Two batches of dehulled seeds (each weighing 2.5 kg) were made; the first batch was ground into flour right away, and the second batch was sun-dried for five days before being ground again [14].

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Figure 1: Breadfruit Seeds Being Dehulled.

Preparation of Breadfruit Milk

reported using a traditional Chinese method to prepare milk extract from breadfruit. After the fresh batch was ground, a smooth breadfruit slurry was obtained [15]. After running the slurry through a 0.04 mm sieve, water was added to the mixture to create breadfruit milk. For the dry sample, the same process was used. After 30 minutes of constant stirring boiling, the filtrate was allowed to cool to room temperature.

Production of Breadfruit Yoghurt

In Figure 2, the flowchart for making African breadfruit yoghurt is displayed. The method used was the one documented by [1]. 250 milliliters (250 ml) of prepared breadfruit milk were pasteurized for 15 minutes at 82 oC. Then came the addition of sugar (to taste) and skim milk. A Linsan standard mixer QF-3479 was used to homogenize the samples, and a temperature drop to 42 oC was permitted. The samples were split up into fermenting plates and inoculated with 1% commercial yoghurt culture (a 50:50 blend of Lactobacillus bulgaricus and Streptococcus thermophilus) once they had cooled to 42 oC. After covering them with foil, they were incubated for 16 hours at 32 oC. To halt fermentation, the mixture was put in the refrigerator at 4 oC at the conclusion of the incubation period (Figures 3 and 4).

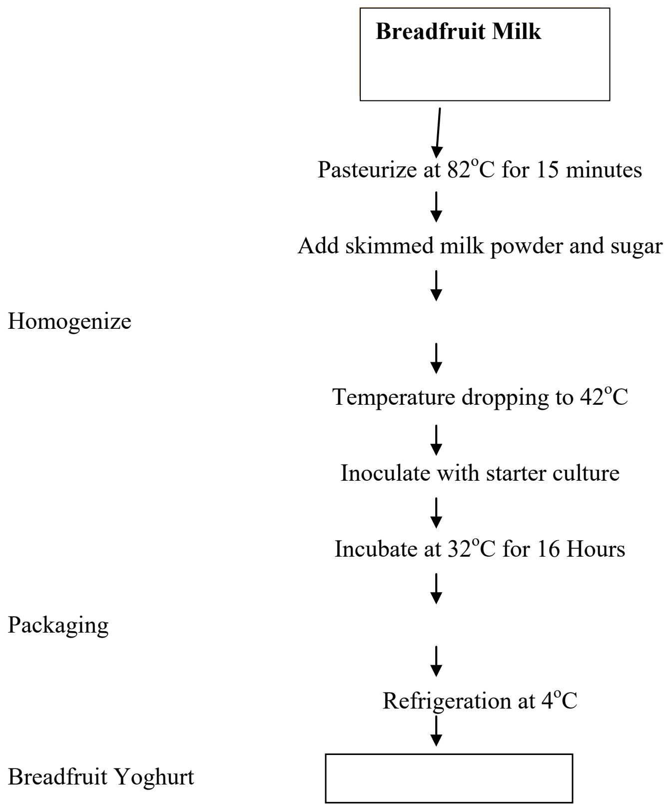

Figure 2: Flow Chart for Production of Yoghurt from Breadfruit Milk.

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Figure 3: Yoghurt from Fresh African Breadfruit Seeds.

Figure 4: Yoghurt from Dried African Breadfruit Seeds.

Nutritional Analysis of Breadfruit Yoghurt

The AOAC [16] standard procedures were employed to analyze the yoghurt samples' proximate composition. Every analysis was carried out three times.

Determination of Moisture Content

The yoghurt samples were divided into two milliliter portions and put into dry, weighed crucibles. After being placed in a moisture extraction oven set at 105 oC for two hours, the crucibles containing the samples were removed. After being allowed to cool in a desiccator, the filled crucibles were weighed. It was continued until a consistent weight was achieved. According to the weight loss experienced by each sample corresponded to its moisture content, as demonstrated by equation 1 [17].

$$\% \text{ moisture content} = \frac{\text{initial wt of sample} - \text{wt of oven dried sample}}{\text{initial wt of sample}} \text{ x } 100$$

Equation 1

Determination of Ash Content

Each yoghurt sample, weighing two milliliters, was put into a dry porcelain crucible. After being burned on a Bunsen burner, these were fired in a muffle furnace at 600 degrees Celsius for six hours, or until the samples turned completely white. After an hour of cooling in a desiccator, the crucible containing the ash was weighed again [18]. Equation 2 illustrates how the percentage of weight lost during combustion was determined using the ash content.

$$\% \text{ ash content} = \frac{\text{wt of ash}}{\text{wt of sample}} \text{ x } 100 \qquad \text{Equation 2}$$

Determination of Crude Protein

Kjeldahl techniques, as outlined by Onwuka, were used to ascertain each sample's total nitrogen and protein content. A-0.2 ml of the sample was put into a Kjeldahl digestion flask together with a few glass beads, one gramme of copper sulphate, one Kjeldahl tablet, and 25 ml of strong sulfuric acid [19]. A fume closet was used to digest the mixture until a clear solution was produced. After carefully transferring each digest into a 100 ml volumetric flask, distilled water was added to reach the mark. A micro Kjeldahl (Markham distillation device) unit was filled with an identical amount of 40 % NaOH solution and filled with 50 millilitres of the digest, which was then distilled. A-10 % boric acid solution containing three drops of mixed indicator (bromocresol green-methyl red) was filled with the distillate after it was collected. 50 millilitres of distillate in total were gathered, and after being titrated against 0.02 N H2SO4 solution, the original blueish-green colour changed to pink (the end-point). Equation 3 shows the percentages of total nitrogen and crude proteins that were determined.

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$$\% \text{ nitrogen} = \frac{T \times N}{W} \times \frac{Vf}{Va} \times \frac{14}{1000} \times 100$$ Equation 3

Where
N = normality of the acid
V_f = total volume of digest
V_a = volume of sample digested
W = weight of digested sample
T = volume of acid used to titrate the sample
C = correction factor (6.25)

Determination of Crude Fat Content
The Soxhlet fat extraction technique was used, as reported by and AOAC [16, 20]. The A-250 ml clean boiling flask was labeled and allowed to cool in a desiccator after being dried for 30 minutes at 105 oC in the oven. A sample of yogurt, two milliliters, was weighed and placed into a thimble with a label. Weighing was done on the matching, labeled boiling flask (W1). Thirty milliliters of petroleum ether were added to the boiling flask. After lightly plugging the extraction thimble with cotton wool, the Soxhlet apparatus was put together and left to reflux for six hours. After carefully removing the thimble, the petroleum ether in the container's top was decanted into a conical flask so that it could be reused. After the flask was almost completely free of petroleum ether, it was taken out of the oven and dried for an hour at 105 degrees Celsius. It was then moved to a desiccator to cool before being weighed (W2). The formula 4 was used to determine the percentage of fat [18]:

$$\% \text{ Fat} = \frac{W2 - W1}{\text{weight of sample}} \times 100$$ Equation 4

Determination of Crude Fiber Content
Each 250 ml beaker held 200 ml of 0.125 M tetraoxosulphate (IV) acid, and two milliliters (2 ml) of the yoghurt sample were added. A muslin cloth covered with a Buckner funnel was used to filter the mixture after it had been heated to between 70 and 90 degrees Celsius for two hours in a steam bath. The residue was put into a beaker with 200 milliliters of potassium hydroxide after being cleaned three times with hot water to get rid of the acid. After heating the residue once more and filtering it, it was cleaned three times with hot water and then with alcohol and water. The final residue was dried at 120 oC to a constant weight in a crucible that had been previously weighed. After 30 minutes of burning at 550 degrees Celsius in a muffle furnace, it was cooled in a desiccator and weighed. According to equation 5 the percentage of crude fiber was as follows [18, 20]:

$$\% \text{ crude fibre} = \frac{\text{Wt of oven dried} - \text{Wt of ash}}{\text{initial wt of sample}} \times 100$$ Equation 5

Carbohydrate Content Determination
The variation in equation 6 was used to calculate the samples' carbohydrate content:

% CHO = (% MC + % fat + % protein + % fibre + % crude ash) Equation 6
Where CHO = carbohydrate
MC = moisture content

Metabolizable Energy (kJ/100g)
Equation 7 was utilized to calculate the amount of metabolic energy, as stated by Tukura and Obliva [21].
Metabolizable energy = (protein x 17 + fat x 37 + carbohydrate x 17) Equation 7

Determination of Minerals and Vitamin C
Determination of the Mineral Profile of the Samples: The method presented by Gyar and Owaku was used to determine the mineral contents of samples of breadfruit yoghurt [22]. A 250 mL beaker with a borosilicate capacity was previously cleaned, and a portion of the sample ash weighing about 0.2 g was added for digestion. The weighed sample was placed in the beaker and thirty milliliters of concentrated nitric acid were added. The sample was put on the hot plate in the fume cupboard for digestion along with concentrated nitric acid. The beaker and its contents were allowed to cool after digestion. After adding and further digesting 20 milliliters of nitric acid in the fume cupboard, the mixture was allowed to cool to room temperature. After filtering the mixture, a 250 mL borosilicate beaker was used. The other samples were digested according to the same protocol. For Atomic Absorption Spectrophotometric (AAS) analysis, all of the digested samples were put into borosilicate beakers that had been previously cleaned. From each of the 100 mg/L stock solutions of the metal specimen, standards of iron, manganese, zinc, calcium, iodine, magnesium, phosphorus, potassium, and sodium were prepared at concentrations of 0.2, 0.4, 0.6, 0.8, and 1.0 mg/L. Atomic Absorption Spectrophotometry was used to analyze the digested sample filtrate as well as the set of standard solutions. With the help of SOLAR software and the UNICAM 929 London Atomic Absorption Spectrophotometer, the metals in the sample could be detected down to 0.0001 mg/L. Cathode lamps containing iron, zinc, phosphorus, calcium, and other elements were used to analyze the corresponding mineral ions present in the filtrates and standards. Fuel made of nitrous oxide and acetylene was used to create the flame. For both the standards and the sample filtrate, the absorbance was measured at 650 nm. A Schoniger flask was filled with twenty-five milligrams of the sample, which was then digested using concentrated nitric acid. To guarantee that all of the phosphorus pentoxide was converted to orthophosphate, the mixture was brought to a boil for one minute. A resin column measuring 10 cm in length was filled with the solution, and the filtrate was gathered. Two milliliters of ammonium molybdate were added to a ten milliliter Pyrex test tube, and the absorbance of the filtrate and standards was measured at 650 nm [23].

Determination of Vitamin C
The AOAC method was utilized to determine the amount of vitamin C [24]. The sample was taken out of the refrigerated storage chamber at a temperature lower than 4 oC and allowed to reach the atmospheric condition on the bench. With care

and a pestle, the sample was pressed into a completely homogenous paste in the mortar to prevent it from balling up. A 10 mL beaker was filled with a 0.10 g portion of the sample, which was then extracted in the manner described below: A 16 x 126 mm test tube was filled with 0.1 g of the sample and 0.05 g of ascorbic acid (an antioxidant). The test tube was vortexed for 30 seconds after five milliliters of alcohol—which was created by combining 90.2 % ethanol, 4.9 % methanol, and 4.9 % isopropanol—and 0.5 milliliters of 80 percent KOH (W/V) were added. Following a nitrogen flush, the test tube was sealed and allowed to incubate for 30 minutes at 70 degrees Celsius in a water bath with periodic vortexing. After that, the tube was submerged in an ice bath for five minutes. The test tube was filled with three milliliters (3 mL) of deionized water and five milliliters (5 mL) of hexane. It was vortexed for thirty seconds and centrifuged for ten minutes at 1000 rpm. Two more times, using five milliliters of hexane each time, the residue was extracted using the hexane from the upper layer that had been moved to a new test tube. By letting the extract evaporate in a nitrogen-flowing water bath, it was concentrated to 1 milliliter. Under standard operating conditions, the concentrated extract was examined for vitamin content using an HP (Hewlett Packard) Gas Chromatography fitted with 1206 Software. The instrument was calibrated using specific standards using the setup indicated in Table 1. Vitamins in the samples were identified and quantified using an enhanced integrator based on the chromatograms of the extract and the mixture of standards; the result was expressed in mg/100g of sample [23].

Table 1: GC Conditions for Vitamins Profile.

Injection Temperature:	Split Injection
Split Ratio	20:1
Carrier Gas	Nitrogen
Flow Rate:	1.0 ml/min
Inlet Temperature:	250°C
Column Type:	HP 5
First Ramp	at 10°C/min for 20 min, maintained for 4 min.
Second Ramp	at 15°C/min for 4 min, constant for 2 min.
Column Dimensions :	30 m x 0.25 mm x 0.25 m
Oven program:	Initial at 50°C for 2 minutes
Detector:	FID
Detector Temperature:	320°C
Hydrogen Pressure:	20 psi
Compressed Air:	30 psi
GC HP 6890 Powered with HP Chem Station Rev. A 09.01 (1206) Software.	

Statistical Analysis

The SPSS software version 23 was used to statistically analyze the obtained triplicate data. Fisher's Least Significant Difference was utilized to find the separation of the means at (p≤0.05) after mean values were calculated and One-Way ANOVA was performed [25]. The data analysis was conducted by Dr. Emit, Emmanuel Okon, the Director of Information and Communication Technology, Abia State Polytechnic, Aba.

3. Results and Discussion

Nutritional Composition of Milk and Yoghurt Samples from Fresh and Dried African Breadfruit Seeds

Table 2 Displays the Findings of the Proximate Composition of Milk Made from Both Fresh and Dried African Breadfruit Seeds.

Table 2: Proximate Composition of Milk Samples from Fresh and Dried African Breadfruit Seeds.

Sample	Parameter						
	CHO	Crude Protein	Fat	Fibre	Ash	Moisture	Energy (kJ/100g)
MFABS	14.64 ± 0.11[b]	3.07 ± 0.08[b]	1.56 ± 0.00[b]	0.92 ± 0.06[b]	1.68 ± 0.00[a]	78.23 ± 0.11[a]	351.39 ± 10.45[b]
MDABS	28.34 ±1.31[a]	3.19 ± 0.00[a]	2.61 ± 0.01[a]	1.34 ± 0.17[a]	0.93 ± 0.08[b]	63.59 ± 0.12[b]	632.58 ± 11.23[a]
LSD	**2.37**	**0.58**	**0.72**	**0.33**	**0.47**	**3.28**	**28.33**
Means with the same superscripts in the same column are not significantly (p≤ 0.05) different from each other							
CHO = Carbohydrate							
MFABS = Milk from Fresh African Breadfruit Seeds							
MDABS = Milk from Dried African Breadfruit Seeds							
LSD = Least Significant Difference at P≤0.05							

Crude Protein Content: Compared to dried African breadfruit milk, which has a protein level of 3.19 percent, fresh African breadfruit milk had a lower crude protein content (3.07 %) (P≤0.05). In comparison to the protein content of melon seed milk (3.67 %) and soybean milk (3.3 %) reported by Onweluzo and Owo, the protein content of dried African breadfruit milk is higher than that of benniseed milk (2.86 %) and soybean milk (2.17 %) reported by Nnam [26, 27]. The drying process was blamed for the difference. Nutrients may benefit from or suffer from drying. It appears that variations in seed variety, composition, extraction technique, and pre-extraction treatments account for these variations in protein values [1].

Crude Fat Content: The findings indicate that the fat content of dried African breadfruit milk is marginally (P≤0.05) higher than that of fresh African breadfruit milk. The two samples' fat contents differed greatly. The fat content of dried African breadfruit milk (MDABS), an oil seed, was 2.61 %. With only 1.56 % fat, the fresh African breadfruit milk (MFABS) had a lower fat content. According to Yoon *et al*., the low-fat levels found in MDABS and MFABS milk may prolong shelf life by lowering the likelihood of rancidity [28]. The milk samples with legumes had very high levels of crude fat. According to Agim-Ezenwanta *et al*., milk derived from legumes has no cholesterol and is a good source of healthy polyunsaturated lipids that lower the risk of heart disease and stroke among other related health benefits [1]. This might be a reflection of the protein and carbohydrate losses brought on by drying. The two milk samples' fat content was surprisingly lower than the minimum (3 %) stipulated by the Codex Alimentarius Standard [29].

Ash Content: The ash level of fresh African breadfruit milk was 1.68 %, which was marginally higher (P>0.05) than that of MDABS (0.93 %). The two milks' ash contents differed significantly from one another. Though generally low, the total ash content of the milk samples was higher than that of the soybean (0.53 %), lima bean (0.45 %), and Bambara groundnut (0.35 %) milks. The mineral content of the milk samples is reflected in the ash content. The chelating effect of the anti-nutritive components in the raw food materials may have contributed to the low ash content of the legume milk samples. It's possible that the release and availability of the mineral ions won't be reasonably guaranteed by the heat inactivation of these anti-nutrients [30]. Given their crucial role in intermediate metabolism, it follows that legume milk would require fortification with certain minerals, particularly calcium [31].

Moisture Content: Fresh African breadfruit milk had a higher moisture content (78.23%) than the dried sample (63.59 %), with a statistically significant difference. The anticipated variation resulted from the seeds being dried before being extracted. According to Agim-Ezenwaka *et al.*, the soymilk, lima milk, and bambara groundnut milk had respective moisture contents of 92.05 %, 91.25 %, and 90.40 % [1].

Crude Fibre Content: The outcome demonstrated a significant difference between MDABS's (1.34 %) and MFABS's (0.92 %) fiber contents. According to Agim-Ezenwaka *et al*., the fiber contents of both milks were higher than the soymilk's (0.45%) fiber content but lower than the lima milk's (1.53 %) and bambara milk's (1.45 %) fiber content [1]. For the stomach to work efficiently during digestion, dietary fiber is necessary. Numerous illnesses, such as colon cancer, coronary heart disease, obesity, diabetes, and gastrointestinal disorders, may benefit from its use in both treatment and prevention. One of the benefits of legume milk over animal milk is its high fiber content [1].

Carbohydrate Content: Compared to dried African breadfruit milk (28.34 %), fresh African breadfruit milk has less carbohydrates (14.64 %). The observed higher (P<0.05) carbohydrate content in dried African breadfruit milk as opposed to fresh African breadfruit milk could be attributed to drying. The carbohydrate content of lima milk (2.8 %), soymilk (1.31 %), and Bambara groundnut milk (4.10 %) was reported by Agim-Ezenwaka *et al*., [1]. The samples' carbohydrate content suggested that the body might use the milk from legumes as a source of energy. Unlike cow milk, the sugar profile of legumes does not contain lactose, making them perfect for people who are lactose intolerant. Nonetheless, the majority of research on the carbohydrates found in legumes is primarily limited to sugars like sucrose, raffinose, and starchyose. These legumes' oligosaccharides function as prebiotics as well since the LAB can use them during fermentation [32].

Metabolizable Energy: The outcome indicated that the energy values of MDABS (632.58 kJ/100 g) and MFABS (351.39 kJ/100 g) differed significantly. The observed higher (P<0.05) energy value in dried African breadfruit milk compared to fresh African breadfruit milk could be attributed to drying. Table 3 Displays the Findings of the Proximate Composition of Dried and Fresh African Breadfruit Yoghurt.

Table 3: Proximate Compositions and Energy Values of Yoghurt Samples from Fresh and Dried African Breadfruit Seeds.

Sample	Parameter						
	CHO	Crude Protein	Fat	Fibre	Ash	Moisture	Energy (kJ/100g)
YFABS	8.16 ± 0.11[b]	3.55 ± 0.08[b]	1.64 ± 0.01[b]	0.73 ±0.01[a]	0.94 ± 0.04[b]	86.73 ± 0,01[a]	199.07 ± 4.23[c]
YDABS	7.15 ± 0.21[c]	3.56 ± 0.06[b]	1.62 ± 0.02[b]	0.68 ± 0.03[a]	0.96 ± 0.03a[b]	85.71 ± 0.21[b]	242.01 ± 2.28[b]
CY	8.77 ± 0.03[a]	3.68 ± 0.00[a]	1.71 ± 0.01[a]	0.13 ± 0.00[b]	1.05 ± 0.03[a]	84..79 ± 0.01[c]	274.92 ± 3.33[a]
LSD	**0.472**	**0.112**	**0.221**	**0.052**	**0.091**	**0.433**	**10.853**

Means with the same superscripts in the same column are not significantly (p≤ 0.05) different from each other

CHO = Carbohydrate

YFABS = Yoghurt from Fresh African Breadfruit Seeds

YDABS = Yoghurt from Dried African Breadfruit Seeds

CY = Commercial Yoghurt (Control)

LSD = Least Significant Difference at P≤0.05

Crude Protein Content: The protein content of the dried (3.56 %) and fresh (3.55 %) African breadfruit yoghurt did not differ significantly (P ≤ 0.05). The protein values of the two yoghurt samples and the commercial yoghurt, however, differed significantly (Table 3). According to Early and Agim-Ezenwaka *et al.*, the protein contents of both yoghurts are comparatively similar to the 3.5 % and 3.40 % protein contents of yoghurt and soy, respectively [1, 33].

Crude Fat Content: The highest fat content was found in commercial yoghurt (1.71 %). The fat content of dried African breadfruit yoghurt and fresh African breadfruit yoghurt did not differ significantly (P>0.05). Both the fresh and dried African breadfruit yoghurts had fat contents that were less than the recommended minimum for low-fat yoghurts (< 3.5 %) [34]. The low-fat contents recorded may contribute to increased shelf life of both samples by decreasing the chances of rancidity. Fat content has been reported by other researchers to have positive influence on the physical and sensory characteristics and negative impact on the shelf stability of yoghurts [33, 35-37].

Total Ash Content: The ash content of dried African breadfruit and fresh African breadfruit yoghurt did not differ significantly (P ≤ 0.05). This might be because breadfruit is a high-quality source of minerals. The ash contents of both the fresh and dried African breadfruit yoghurt (0.94 % and 0.96 %) are statistically similar to that of commercial yoghurt (1.05 %), suggesting that both yoghurt samples can compete favorably with the commercial yoghurt in terms of mineral quality. The mineral content of the milk samples is reflected in the ash content. The chelating effect of the anti-nutritive components in the raw food materials may have contributed to the low ash content of the legume milk samples. The release and availability of the mineral ions may not be reasonably assured by the heat inactivation of these anti-nutrients. Given their crucial role in intermediate metabolism, it follows that legume milk would need to be fortified with certain minerals, particularly calcium [1].

Moisture Content: The findings in Table 3 indicate that fresh African breadfruit yoghurt had the highest moisture content (86.73 %), which is probably due to the seed used to make the yoghurt having a high moisture content. For this reason, fresh African breadfruit yoghurt serves as a good source of bodily fluids and a means of reducing thirst. Both fresh and dried African breadfruit yoghurt had moisture contents that ranged from 80 % to 86 %, which is typical for most commercial yoghurts. Nonetheless, the moisture content of commercial yoghurts and dried African breadfruit yoghurt differed significantly (P≤0.05).

Crude Fibre Content: The findings indicated that the fiber content of YFABS (0.73 %) and YDABS (0.68 %) did not significantly differ from one another. The present study yielded lower results than the Agim-Ezenwaka et al., report [1]. Compared to yoghurt samples made from breadfruit seeds, CY had the lowest fiber content (0.13 %) and showed a significant difference. For the digestive system to work efficiently, dietary fiber is necessary. Many diseases, such as colon cancer, coronary heart disease, obesity, diabetes, and gastrointestinal disorders, may be treated or prevented with it.

Carbohydrate Content: The amounts of carbohydrates in fresh African breadfruit yoghurt, dried African breadfruit yoghurt, and commercial yoghurt varied significantly (P≤0.05). According to Table 3, commercial yoghurt has the highest value (8.77 %), followed by fresh African breadfruit yoghurt (8.16 %) and dried African breadfruit yoghurt (7.15 %). African breadfruit yoghurt's low carbohydrate content was anticipated because fermentation may have led to a drop in Table 3's carbohydrate contents relative to Table 2's carbohydrate values. Nonetheless, this makes African breadfruit yoghurt a perfect product for helping people lose weight.

Micronutrient Composition of Milk and Yoghurt Samples from Fresh and Dried African Breadfruit Seeds

Micronutrient Composition of Milk Samples from Fresh and Dried African Breadfruit Seeds

Humans require more than 50 milligrams of the primary mineral elements (Na, K, Ca, Mg, and P) daily. It has been determined that trace elements (Fe, Zn, Se, Cu, Mn, Co, and Ni) have biochemical actions and are necessary at concentrations less than 50 mg/day [23].

Phosphorus Content: As indicated in Table 4, the phosphorus content of MDABS (43.81 mg/100g) was considerably higher than that of MFABS (41.36 mg/100g). The types of soil, water, and processing techniques could all be contributing factors to the variation in values. The study's phosphorus contents were noticeably elevated. In cells, phosphorus has a variety of functions [38]. The samples' phosphorus concentrations may be sufficient for people's daily needs. The strengthening substance found in teeth and bones is called hydroxyapatite, which is created when phosphorus and calcium combine. Phospholipids, which give cell membranes their structure, contain phosphorus. The body can use the energy stores it creates from the metabolism of fat, protein, and carbs when it needs them. Phosphorus aids in this process. 700–1000 mg of phosphorus per day are required for adults [39].

Table 4: Micronutrient Compositions of Milk Samples Made from Fresh and Dried African Breadfruit Seeds.

Sample	Parameters (mg/100g)				
	Phosphorus	Calcium	Zinc	Iron	Vitamin C
MFABS	41.36 ± 0.09[b]	38.53 ± 0.11[b]	0.74 ± 0.01[b]	4.81 ± 0.04[b]	0.75 ± 0.10[a]
MDABS	43.81 ± 0.06[a]	39.56 ± 0.06[a]	1.81 ± 0.03[a]	5.94 ± 0.00[a]	0.50 ± 0.02[b]
LSD	**1.232**	**0.735**	**0.562**	**0.717**	**0.112**
Means with the same superscripts in the same column are not significantly (p≤ 0.05) different from each other					
MFABS = Milk from Fresh African Breadfruit Seeds					
MDABS = Milk from Dried African Breadfruit Seeds					
LSD = Least Significant Difference at P≤0.05					

Calcium Content: Table 4 indicates that MDABS had a considerably higher calcium content (39.56 mg/100g) than MFABS (38.53 mg/100g). Because calcium is involved in the structure of the muscular system and regulates vital functions like blood coagulation, heart rate, muscle contraction (locomotor system), brain cell activity, and cell growth, it is an essential nutrient. The following age ranges are listed as having the ideal calcium intake (g/day): 0 to 6 months, 6 to 12 months, 1 to 5 years, 6 to 10 years, 0.8–1.2), 11 to 24 years, pregnant women, 25 to 65 years, 1.0, and over 65 years (1.5) [39-41]. The body's acid-base balance is regulated by the calcium salts [42]. Eating foods high in calcium strengthens the immune system, which facilitates the body's absorption, utilization, and digestion of nutrients. The calcium values found in this study are below the recommended daily intake of 1000 mg for adults aged 19 to 50 and 1200 mg for adults aged 51 and above [43]. However, these values could be increased by either consuming more cocoyam or combining it with other foods high in calcium. Adults with osteomalacia and children with rickets are caused by a severe calcium deficiency.

Zinc Content: Table 4 illustrates that the zinc content of MDABS (1.81 mg/100g) was considerably higher than that of MFABS (0.74 mg/100g). Almost every cell in our body contains zinc. It plays a role in over 100 enzymes' activities. Several enzymes, including carboxypeptidases A and B, carbonic anhydrase, alcohol dehydrogenase, lactate dehydrogenase, malate dehydrogenase, and glutamate dehydrogenase, are composed of zinc. Zinc and certain other divalent metal ions activate the enzymes dipeptidases, alkaline phosphatase, lecithinase, and enolase, among others. Zinc is involved in gene expression as well as the structure of DNA and RNA in cells. Zinc is necessary for healthy growth in developing babies and during adolescence. Because zinc is required for the synthesis of white blood cells, it supports the health of our immune system and lowers the inflammation that can accompany wounds on the skin. A typical diet containing 6–22 mg of zinc per day meets the daily requirement of 5–10 mg [39-41].

Iron Content: Table 4 illustrates that the iron content of MDABS (5.94 mg/100g) was considerably higher than that of MFABS (4.81 mg/100g). Hemoglobin, the oxygen-carrying transport protein found in red blood cells, and myoglobin, the pigment found in muscle tissue, both contain iron. The metal is a necessary component of the daily diet because it is found in many enzymes, including peroxidase, catalase, hydroxylases, and flavine enzymes. Enzymes in the brain that are involved in the synthesis of neurotransmitters—which carry messages throughout the body—benefit from iron.

The daily requirement for iron is between 1.5 mg and 2.2 mg, depending on the age and gender of the individual [40]. To meet this daily requirement, the amount of iron in milk must be between 15 and 18 mg per day [39]. Iron-fortified cereals (flour, bread, rice, and pasta products) containing 55–130 mg/kg of iron are advised for those who need higher amounts of iron (children, women before menopause, pregnant women, and nursing mothers) [40, 41].

Vitamin C Content: Table 4 indicates that MFABS (0.75 mg/100g) had a significantly (p ≤ 0.05) higher vitamin C content than MDABS (0.50 mg/100g). Water-soluble vitamin C is directly absorbed into the bloodstream after being absorbed with water. While vitamin B12 is absorbed in the lower part of the small intestine, the majority of water-soluble vitamins are absorbed in the upper portion of the intestine. It is crucial to get enough water-soluble vitamins each day because the body normally does not store them for long periods of time (with the exception of vitamin B12) and excretes excess [23]. The examined breadfruit milks' vitamin C content falls outside of this range. Adult males have an RDA of 90 mg of vitamin C per day, while adult females have an RDA of 75 mg. Ascorbic acid, another name for vitamin C, is a coenzyme that is required for the synthesis and utilization of specific amino acids. Collagen, the most abundant protein in the body, is made possible by vitamin C. As an antioxidant, vitamin C may help lower the risk of developing chronic illnesses like cancer and heart disease. It also aids in the breakdown of histamine, which causes the inflammation associated with many allergic reactions, and the absorption of iron from plant foods like grains and cereals. By facilitating the production of white blood cells in our bodies, vitamin C supports the health of our immune system. The idea that high doses of vitamin C can prevent corona virus disease and cure the common cold has been fostered by the blood cells' ability to fight infections and boost immunity [39]. According to David-Chukwu et al., the recommended daily intake (RDI) of vitamin C is 50–55 mg for infants (0–12 months), 60–90 mg for children and teenagers, and 100 mg for adults (~ 52 years) [23]. Additionally, pregnant and lactating women should take 150 mg and 100 mg of vitamin C daily, respectively.

Micronutrient Composition of Yoghurt Samples from Fresh and Dried African Breadfruit Seeds

Table 5 displays the findings of the micronutrient composition analyses of fresh and dried African breadfruit yoghurts.

Table 5: Micronutrient Compositions of Yoghurt Samples Made from Fresh and Dried African Breadfruit Seeds.

Sample	Parameters (mg/100g)				
	Phosphorus	Calcium	Zinc	Iron	Vitamin C
YFABS	39.27 ± 0.04[c]	35.71 ± 0.01[c]	0.70 ± 0.01[b]	1.76 ± 0.06[b]	0.62 ± 0.02[a]
YDABS	41.31 ± 0.01[b]	36.32 ± 0.11[b]	0.72 ± 0.00[b]	1.80 ± 0.01[b]	0.53 ± 0.01[b]
CY	48.47 ± 0.01[a]	49.81 ± 0.01[a]	1.27 ± 0.05[a]	2.32 ± 0.03 [a]	0.56 ± 0.01[b]
LSD	**1.214**	**0.417**	**0.232**	**0.345**	**0.055**
Means with the same superscripts in the same column are not significantly (p≤ 0.05) different from each other					
YFABS = Yoghurt from Fresh African Breadfruit Seeds					
YDABS = Yoghurt from Dried African Breadfruit Seeds					
CY = Commercial Yoghurt (Control)					
LSD = Least Significant Difference at P≤0.05					

Phosphorus Content: The phosphorus contents of fresh African breadfruit yoghurt (39.27 mg/100g), dried African breadfruit yoghurt (41.31 mg/100g), and commercial yoghurt (48.47 mg/100g) were found to differ significantly (P<0.05). The processing technique used may be the reason why the commercial yoghurt has the highest value. The levels of phosphorus were noticeably elevated. However, as Tables 4 and 5 demonstrate, the phosphorus contents of milk samples of breadfruit seeds were higher than those of yoghurt samples of breadfruit seeds. The types of soil, water, and processing techniques could all be contributing factors to the variation in values [43].

Calcium Content: The calcium contents of fresh African breadfruit yoghurt (35.71 mg/100g), dried African breadfruit yoghurt (36.32 mg/100g), and commercial yoghurt (49.81 mg/100g) were found to differ significantly (P<0.05). However, as Tables 4 and 5 demonstrate, the calcium content of milk samples of breadfruit seeds was higher than that of yoghurt samples of breadfruit seeds. The types of soil, water, and processing techniques could be the cause of the variations in values (Eze and Njoku, 2018). Because it plays a role in the structure of the muscular system and regulates vital functions like blood coagulation, heart rate, brain cell activity, and cell growth, calcium is a necessary nutrient. According to Belitz *et al.*, Blake, Adamu *et al.*, the following age groups have the recommended calcium intake (g/day): birth to 6 months (0.4), 6 to 12 months (0.6), 1 to 5 years (0.8), 6 to 10 years (0.8–1.2), 11 to 24 years and pregnant women (1.2 to 1.5), 25 to 65 years (1.0), and over 65 years (1.5) [39-41]. The body's acid-base balance is regulated by the calcium salts [23]. Eating foods high in calcium strengthens the immune system, which facilitates the body's absorption, utilization, and digestion of nutrients. The results of this study's analysis of calcium yielded values that fell short of the recommended daily intake of 1000 mg for adults aged 19 to 50 and 1200 mg for adults aged 51 and above [42]. However, it might be enhanced by either consuming more cocoyams or balancing them with other calcium-rich foods. According to rickets in children and osteomalacia in adults are caused by a severe calcium deficiency [44].

Zinc Content: Zinc contents of fresh African breadfruit yoghurt (0.70 mg/100g), dried African breadfruit yoghurt (0.72 mg/100g), and commercial yoghurt (1.27 mg/100g) varied significantly (P<0.05). The zinc contents of YFABS and YDABS, however, did not differ significantly from each other, but they did differ significantly from CY's zinc content. The freshness and dryness of the seeds before milk extraction may have caused this shift in zinc content in the yoghurt samples. Because zinc is required for the synthesis of white blood cells, it supports the health of our immune system

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and lowers the inflammation that can accompany wounds on the skin. A typical diet containing 6–22 mg of zinc per day meets the daily requirement of 5–10 mg [39-41]. Zinc is necessary for healthy growth in developing babies and during adolescence.

Iron Content: The iron contents of fresh African breadfruit yoghurt (0.76 mg/100g), dried African breadfruit yoghurt (0.80 mg/100g), and commercial yoghurt (2.32 mg/100g) were found to differ significantly (P<0.05). The iron contents of YFABS and YDABS, however, did not differ significantly from each other, but they did differ significantly from CY's iron content. The freshness and dryness of the seeds before milk was extracted, in addition to the source, may have contributed to this shift in iron content in the yoghurt samples. African breadfruit will still raise the body's iron intake even though it is a poor source of iron [10]. The daily requirement for iron is between 1.5 and 2.2 mg, depending on the age and gender of the individual [40]. To meet this daily requirement, the amount of iron in the diet needs to be between 15 and 18 mg [39]. Enough iron is supplied to those who need more (children, women before menopause, pregnant or nursing women), and iron-fortified cereals (flour, bread, rice, and pasta products) containing 55–130 mg/kg of iron are advised.

Vitamin C Composition of Yoghurt Samples from Fresh and Dried African Breadfruit Seeds

There are notable (P≤.0.05) variations in the vitamin C content between fresh and dried African breadfruit yoghurts according to the vitamin composition analysis. Vitamin C levels were higher in fresh African breadfruit yoghurt (0.62 mg/100g) than in dried African breadfruit yoghurt (0.53 mg/100g). Given that vitamin C is light sensitive, the notable difference could be the result of different processing methods. Ascorbic acid, another name for vitamin C, is a coenzyme that is required for the synthesis and utilization of specific amino acids. Collagen, the most abundant protein in the body, is made possible by vitamin C. As an antioxidant, vitamin C may help lower the risk of developing chronic illnesses like cancer and heart disease. It also aids in the breakdown of histamine, which causes the inflammation associated with many allergic reactions, and the absorption of iron from plant foods like grains and cereals. By facilitating the production of white blood cells in our bodies, vitamin C supports the health of our immune system. The immune-boosting function of these blood cells has led to the belief that high vitamin C dosages can prevent corona virus disease and treat colds, among other viral diseases [5]. According to David-Chukwu *et al.*, the recommended daily intake (RDI) of vitamin C is 50–55 mg for infants (0–12 months), 60–90 mg for children and teenagers, and 100 mg for adults (~ 52 years) [23]. Additionally, pregnant and lactating women should take 150 mg and 100 mg of vitamin C daily, respectively [45].

4. Conclusion and Recommendations

Conclusion: Due to a number of factors, including the high cost of milk, the need for protein in developing nations, the prevalence of lactose intolerance, and low milk production in West Africa to meet population demand, efforts were made to find alternative sources of protein in legume seeds and to produce "imitation milk." Breadfruit milk, a plant protein that is easily accessible to rural populations, can be processed into yoghurt at a low cost of production using straightforward processing methods.

The study's findings have demonstrated, among other things:
• Yoghurt can be made using inexpensive, easily accessible breadfruit milk (a plant protein) and basic processing techniques for rural residents.
• You can use both fresh and dried seeds to make breadfruit yoghurt.
• That breadfruit yoghurt is a good source of bodily fluid and a thirst quencher due to its noticeable moisture content.
• African breadfruit yoghurt's high protein content, found in both fresh and dried forms, can considerably lower the need for protein in developing nations.
• The breadfruit yoghurt's low carbohydrate content makes it a great product for people who are overweight.

Recommendations

More study is required to increase the benefits of breadfruit yoghurt by fortifying it with minerals under controlled conditions. This allows for the controlled fortification of fresh and dried African breadfruit yoghurts to increase their mineral content without compromising the integrity of other nutrients. Iron and calcium salts are typically used to fortify vegetable milk preparations.

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