Comparative Study on the Proximate and Selected Sugar Composition of Raw and Processed Breadfruit

Abstract

Introduction: African bread fruit possesses great promise as a dietary source for humans. Its seeds, when processed are considered to be nutritious and healthy. There are limited information on the sugar profiles of African breadfruit, has limited its utilization as a dietary source for humans

Objective: The study evaluated the proximate composition and sugar profiles of raw and processed breadfruit.

Methods: The samples used were the raw, boiled and toasted form of breadfruit. Standard procedures were followed for the proximate composition and gas chromatography was used to determine the sugar composition. The statistically differences between the groups at $p<0.05$ was tested using ANOVA.

Results: The study's findings showed that in comparison to the boiled and toasted forms, the raw form had significantly higher percentage of carbohydrate (81.10), crude protein (1.73), ash (2.93) and crude fibre (4.80). The boiled had significantly higher moisture (19.49) than raw and toasted forms. The sugar profiling revealed that the concentration(mg/100g) of glucose (13.77), and xylose (3.42) was significantly higher in the raw compared to the processed forms. D-fructose (3.93) was significantly higher in the boiled form while D-Galacturonic acid (5.76) and D-Glucuronic acid (8.57) were significantly higher in the toasted form.

Conclusion: The findings suggest that breadfruit is a good source of carbohydrates and can be used as sustainable food and can help to alleviate malnutrition among humans.

Keywords: African bread fruit, sugar composition, raw and processed breadfruit, Proximate composition

Introduction

Treculia africana, often known as African breadfruit, is a crop that is widely spread in West and Central Africa. It is an evergreen tree that is found in humid, tropical and subtropical forests [1]. It is a member of the Moraceae family and belongs to genera Treculia [2]. In many tropical regions, breadfruit is a staple food due to its starchy and nutritional properties [3]. Breadfruit is rich in various nutrients, including carbohydrates, proteins, vitamins, and minerals. It is an important staple crop that supports sustainable agriculture and food security [4]. Breadfruit is devoid of gluten, low in fat and cholesterol and abundant in complex carbohydrates [5]. In comparison to white potatoes, white rice and white bread, it has a mild glycemic index, thus it is good for diabetes prevention. At every stage of development and maturity, breadfruit is an extremely versatile fruit that can be prepared and consumed by humans. Mature breadfruit can be prepared in a variety of ways including baking, frying, boiling and traditional fire cooking [5].

Numerous investigators found that unprocessed breadfruit and its flour have a lower glycemic index(GI) than wheat and rice flour. This could be attributed to its high dietary fibre which may help to slow down the gastrointestinal tract absorption of glucose [6].

Carbohydrates are a vital macronutrient that serve as the primary source of energy for the body and play a crucial role in various physiological functions. They are composed of sugar molecules, including simple sugars (monosaccharides) like glucose and fructose, as well as complex carbohydrates (polysaccharides) such as starch and dietary fibre [7]. Although not metabolized by the body, dietary fibre is an essential component of a healthy digestive system. It adds bulk to diet, facilitates bowel movements and lowers blood sugar and cholesterol level [8,20,21].

Critical global challenges include food scarcity and low intake of appropriate nutrition, particularly among vulnerable populations like the poor and undernourished children. Identifying nutrient rich, sustainable food sources that can enhance food security and dietary quality is necessary to address these problems. However, a comprehensive understanding of breadfruit's nutritional profile, particularly its carbohydrate composition is essential in using it as a sustainable food source. Consequently, the goal of the study is to do a comparative study of the proximate and selected sugar composition of raw and processed breadfruit, providing important information that will support dietary planning and encourage the use of breadfruit as a nutritious and sustainable food source.

2.0 Methodology

Sample Collection and Preparation

Breadfruit was gotten from Mile 3 Market in Port Harcourt, Nigeria. Fifty grams (50g) each of the sample was measured into three 250ml beakers. The first beaker contained the boiled breadfruit, which was made by boiling 50g of the sample in 200ml water for an hour (the water was not salted) before peeling and weighing. The second beaker contained raw breadfruit, which was toasted for 10minutes at 60^{o}C before cooling, peeling and weighing. The third beaker had the raw, unprocessed breadfruit. All samples were kept in sealed container for further use.

Proximate analysis

Standard procedures were utilized for the determination of percentage crude protein, moisture, ash, crude fibre, crude lipid and carbohydrate content.

Determination of simple sugars

Sample Preparation for GC analysis

The sample (20mg) was dried for two hours at 55^{o}C in a rotating vacuum concentrator. This was dissolved in 100µl of pyridine and immersed in an ultrasonic bath for 5minutes. The sample was thoroughly mixed for 20seconds using a vortex and underwent centrifugation (12,000x g, 10min, 20^{o}C) to eliminate any insoluble material. 800µl of the supernatant was reserved for the oximation-silylation process.

Standard Sugar Preparation for GC analysis

Pyridine (800µl), was used to dissolve 10mg of sugar (glucose, fructose, mannose, or sucrose) to create individual standard solutions. These solutions underwent oximation-silylation process in preparation for Gas chromatography-mass spectroscopy (GC-MS) analysis.

Procedure for selected sugar determination

O- methyl hydroxylamine-hydrochloride (50mg) was used to oximate the samples' sugars, which were incubated at 95°C for 45 min on a heat plate. Subsequently to each oximated sample, silylated reagent (200µl) and N,O-Bis(trimethylsilyl)trifluoroacetamide (BSTFA), was added and incubated for 30minutes at 90^{o}C. For sucrose, it took 60 minutes to silylate it. Then, the samples were centrifuged (8000× *g*, 10 min, 20 °C). After centrifuging, the derivatives underwent GC-MS analysis using an Agilent 6890 gas chromatograph and a 5973 MS detector. The injector temperature was set at 250^{o}C, the oven temperature ramp was set to 200^{o}C to 230 ^{o}C and the SCAN mode was set to run from m/z 35 to 450. Utilizing an Agilent 6820 gas chromatograph, the sugar content was ascertained.

Statistical Analysis

All collected data were statistically analysed, and results were reported as mean ± standard deviation. A Turkey test was conducted after a one-way analysis of variance (ANOVA) to ascertain whether there was a statistically significant difference within the groups using SPSS package version 21, $p < 0.05$ were seen as statistically significant.

3.0 Results

Table 1. Proximate Composition of Raw and Processed Breadfruit (%)

Compound	Raw Breadfruit	Boiled Breadfruit	Toasted Breadfruit

Moisture	8.61 ± 0.01^{a}	19.49 ± 0.01^{b}	12.03 ± 0.01^{c}
Ash	2.93 ± 0.02^{a}	1.85 ± 0.01^{b}	1.73 ± 0.01^{c}
Crude Lipid	0.84 ± 0.01^{a}	0.97 ± 0.01^{b}	4.75 ± 0.03^{c}
Crude Protein	1.73 ± 0.01^{a}	1.26 ± 0.01^{b}	0.90 ± 0.01^{c}
Crude Fiber	4.80 ± 0.01^{a}	4.11 ± 0.01^{b}	3.74 ± 0.01^{c}
Carbohydrate	81.10 ± 0.06^{a}	72.93 ± 0.01^{b}	72.93 ± 0.01^{b}

Values are expressed as mean ± Standard Deviation (SD) in triplicate. Values with different superscript (a) show significant difference when comparing raw with boiled and toasted. Values with different superscript (b) show significant difference when comparing the boiled with the raw and toasted. Values with different superscript (c) show significant difference when comparing toasted with boiled and raw.

The moisture content was significantly higher in boiled than the raw and toasted forms. The ash, crude protein and crude fibre were significantly different in the raw form (2.93, 1.73 and 4.80 respectively) when compared to the boiled and toasted breadfruit. The crude lipid content was significantly higher in the toasted (4.75%) when compared to the raw (0.84) and boiled (0.97). Carbohydrate content was significantly different in the raw (81.10), when compared to the boiled (72.93) and toasted (72.93).

Table 2. Selected Sugar composition of raw and processed breadfruit

COMPOUND	Concentration (mg/100g)		
	Raw Breadfruit	Boiled Breadfruit	Toasted Breadfruit
D-Galacturonic acid	1.46±0.06[a]	3.82±0.09[b]	5.76±0.05 [c]
D-Glucuronic acid	1.67±0.18[a]	2.80±0.01[b]	8.57±0.24 [c]
D-Fructose	2.92±0.04[a]	3.93±0.01[b]	0.68±0.05 [c]
L-Rhamnose	5.68±0.07[a]	2.87±0.01[b]	0.80±0.01 [c]
D-Glucose	13.77±0.22[a]	11.27±0.04[b]	4.41±0.02[c]
D-Galactose	4.38±0.08[a]	1.63±0.02[b]	0.87±0.05[c]
D-Mannose	3.76±0.06[a]	1.84±0.02[b]	0.75±0.01[c]
L-Arabinose	2.29±0.01[a]	0.94±0.02[b]	0.71±0.02[c]
D-Fucose	1.90±0.07[a]	1.36±0.06[b]	1.10±0.02[c]
D-Xylose	3.42±0.02[a]	1.86±0.10[b]	0.46±0.04[c]
D-Glucosamine hydrochloride	0.80±0.06[a]	0.38±0.11[b]	3.25±0.11[c]
D-Galactosamine hydrochloride	0.50±0.01[a]	0.70±0.07[b]	2.88±0.03[c]
D-Mannosamine hydrochloride	0.53±0.18[a]	0.25±0.09[b]	1.52±0.09[c]
Meso-Erythritol	1.81±0.24[a]	1.57±0.05[b]	2.26±0.10[c]

Values are expressed as mean ± Standard Deviation (SD) in triplicate. Values with different superscript (a) show significant difference when comparing raw with boiled and toasted. Values with different superscript (b) show significant difference when comparing the boiled with the raw and toasted. Values with different superscript (c) show significant difference when comparing toasted with boiled and raw

The concentration of D-Galacturonic acid, D-Glucuronic acid and D-Glucosamine hydrochloride was in the order toasted > boiled > raw breadfruit which was significantly different. The toasted form was also significantly higher in Meso-Erythritol, D-Mannosamine hydrochloride and D-Glucosamine hydrochloride when compared to the raw which was also significantly higher than the boiled. The concentration of D-fructose was significant in the order boiled > raw > toasted breadfruit. The raw was significantly higher in D-Glucose, L-Rhamnose, L-Rhamnose, D-Mannose, D-Fucose and D-Xylose when compared to the boiled which was significantly higher than the toasted breadfruit. Glucose concentration(mg/100g) was in the order raw (13.77) > boiled (11.27) > toasted (4.41). The concentration of Galacturonic and glucuronic acid (mg/100g) was as follows: toasted breadfruit (5.76, 8.57) > boiled (3.82, 2.80)> raw (1.46, 1.67) respectively.

4.0 Discussion of Findings

African bread fruit is a very nutritious crop that contains complex carbohydrates and low in fat [6]. The study examined the proximate composition of raw, boiled, and toasted bread fruit. Carbohydrate serves as fuel for energy and physical activities, whereas fats provide additional energy. Proteins are necessary for growth and cell repair. Crude fibre helps the body to eliminate waste, provide a home for bacterial flora, increases food bulk and serves as a carrier for other nutrients [9]. Results from this study shows that the carbohydrate content was high in all the three forms with the raw having the highest value, the crude lipid was high in the toasted as compared with others and the moisture was high in the boiled form as compared with others. These indicate that the method of preparation had a significant effect on the proximate composition of the breadfruit. The boiled breadfruit had higher moisture content than the raw one, possibly because boiling causes water to be absorbed during the cooking process [10]. Food moisture content is a measure of stability and susceptibility of microbial contamination; a high level of moisture content indicates that the food is highly perishable while a low moisture content of food sample is beneficial for storing and preserving nutrients [11]. When compared with the raw, the other forms had lower crude protein concentrations. This could be because heating causes denaturation of some proteins [12]. The values of the boiled (72.93%) and toasted (72.93%) breadfruit carbohydrate content in this study are comparable to those of Osabor et al. [13] who had 59.85-72.66%, while the raw breadfruit's carbohydrate content was greater. The ash content of the raw breadfruit (2.93%) in this study, was close to the study of Tukura and Obliva [11] who had 2.42-2.49%. Similarly, this study's ash content (1.73-2.93%) was lower and the fibre content (3.74-4.80%) was higher than that of Mbah et al. [14] who had ash and fibre content as 3.58% and 1.45% respectively. Oladunjoye et al. [15] had higher fibre (5-5.38%), crude protein (4.31 - 4.85%) and fat (2.11-2.9%) content than the values found in this study.

The concentration of selected sugars present in the raw and processed breadfruit was also examined. Glucose is a frequently used fuel in living organisms. It serves as an energy source. Xylose exhibits antibacterial and antifungal properties. According to Khowala et al. [16], xylose stimulate the development of friendly flora in the intestines, which improves the production and absorption of nutrients and fortifies the immune system to help fight against illnesses. Galactouronic and glucuronic acids are types of uronic acids, which are used in the pharmaceutical, cosmetic and food industries for a variety of purposes including antioxidants, detoxifying and as precursors of ascorbic acid, and chelating agents with anti-cancer properties [17]. This study found out that, there was more glucose in the raw form, fructose was high in the boiled form and more xylose was found in the toasted form. The glucose concentration of this study was within the range of Adewusi et al. [18] while the fructose concentration was lower than what they found out, who had 0.7-1.4 and 0.54-1.0% for glucose and fructose respectively. Golden and Williams [19] had lower glucose (0.22-0.44 mg/100g) and xylose (0.19-0.32 mg/100g) concentration compared to this study.

5. Conclusion

Comparative study on the proximate and selected sugar composition was done on raw and processed African breadfruit and it was found that the raw breadfruit had higher moisture, ash, crude protein, crude fiber and carbohydrate content when compared to the processed breadfruit. In contrast to the raw and boiled, the toasted had higher concentration of crude lipid. In terms of selected sugar composition, raw breadfruit had a higher content of D-glucose when compared to the boiled and toasted. Based on these findings, it suggests that raw breadfruit is a good source of dietary fiber and carbohydrates. Both raw and processed breadfruit are both generally healthy foods with its own uniqueness. The optimal option for a person will vary depending on their dietary requirement and preferences. It is important to consume a variety of foods, as part of a healthy diet.

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