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Comparative Study on the Nutritional and Anti-Nutritional Compositions of Sweet and Bitter Cassava Varieties for Garri Production

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Abstract

A comparative study on the proximate, mineral amino acid and anti nutritional compositions of sweet and bitter cassava varieties was done to ascertain the nutritional quality and safety after 72 h of fermentation for garri production. The sweet cassava variety had higher moisture (8.04±0.74%), crude protein (23.51±0.50%), fat (10.01±0.02%), crude fibre (5.66±0.02%), and ash (0.44±0.10%) contents than the bitter cassava variety with moisture (7.23±0.39%) crude protein (22.74±0.16%), fat (9.54±0.01%), crude fibre (4.13±0.02%) and ash (0.35±0.02%) contents. Of all the minerals analysed, Ca, Mg, P, Zn and Cu had higher contents for the sweet cassava variety than the bitter cassava variety. The amino acid contents of the sweet cassava variety were higher than the bitter cassava variety. The contents of the anti-nutrients were higher for the bitter cassava variety with hydrogen cyanide (20.13±0.09 mgHCN/100g), oxalate (3.27±0.04 mg/100g), tannin (0.3±0.00%), phytate (62.4±1.29 mg/100g), alkaloid (0.32±0.04%), lignin (0.18±0.01 mg/100g) and saponin (0.13±0.01%) as compared to the sweet cassava variety with hydrogen cyanide (7.58±1.25 mgHCN/100g), oxalate (1.30±0.02 mg/100g), tannin (0.2±0.01%), phytate (53.7±0.81 mg/100g), alkaloid (0.27±0.02%), lignin (0.13±0.01 mg/100g) and saponin (0.13±0.01%). The higher nutritional quality and the lower anti-nutrients content demonstrate that the sweet cassava is a better variety for garri production to ensure better health and safety of the consumers.

Keywords: Nutritional; Anti-nutritional; Sweet; Bitter; Cassava varieties; Garri

Introduction

Cassava (*Manihot esculenta Crantz*), is a perennial woody shrub with an edible starchy tuberous root, which grows in tropical and subtropical areas of the world [1]. It is the third largest source of carbohydrates for human food in the world after rice and corn with Africa being its largest continent of production [2]. The roots are primarily produced for food in the form of garri, fufu and lafun. This is because cassava roots are quite high in carbohydrates containing about 60 to 70% for Nigerian cultivars [3]. Cassava is classified on the basis of the level of cyanide content into sweet and bitter cassava varieties [4].

Cassava is often identified as an inferior food crop, as poor people's crop and as a dangerous crop [5]. These myths on cassava were due to some limitations in the crop which include the presence of cyanogenic glucosides (which is broken down to release toxic hydrogen cyanide), low protein content and short harvest shelf-life [6]. Traditionally, most of these constraints have been met through processing. Cassava is processed to remove or reduce the toxic cyanogenic glucosides, improve palatability as well as serve as a means of preservation [7]. Fermentation of cassava is the most important and widely used means of processing cassava [8].

The most typical and popular product which is prepared from fermented cassava pulp is garri. Garri is an important food in West Africa, particularly Nigeria, where it is consumed by an estimated 80 million people [9]. Garri is prepared by grating the enlarged roots of the cassava plant and allowing it to ferment naturally with application of pressure in a jute bag. The fermented mash is roasted with or without palm oil added. The nutritional quality of the traditional fermentation of cassava for garri production is very important because garri has two main disadvantages which are carried over from cassava. The first is the presence of toxic cyanogenic glycosides, the consumption of which may lead to ailments such as tropical ataxic neuropathy and goitre, when consumed over prolonged periods in a low protein diet [10]. The other deficiency is its low content of protein and amino acids (IITA, 1990).

Fermentation enhances the nutrient content of cassava through biosynthesis of vitamins, essential amino acids, proteins and fibre digestibility. It also enhances micronutrient bioavailability and aids in degrading antinutritional factors [11]. Proper nutrients in food enhance optimal health and wellbeing [12]. Antinutrients interfere with the absorption of nutrients in the body [13]. The aim of this study was to investigate the compositions of sweet and bitter cassava varieties fermented for garri production in order to ensure its adequate nutritional quality for better health of the consumers.

Materials and methods

Collection of samples

Freshly harvested sweet and bitter cassava tubers were collected from a local farm in Ekiadolor (Lat 6° 29' N, Long 5° 35' E), Ovia North East Local Government Area of Edo State, Nigeria. The tubers were obtained from 10 – 14 month old plants. They were washed with distilled water and peeled. The cassava pulps were then washed thoroughly and separately grated in a clean cassava grinding machine. The sweet and bitter grated cassava were each transferred into separate jute bags and pressure applied in a press (made from wood and concrete) and left to ferment for three days under room temperature. Samples of the sweet and bitter cassava were taken for analyses in the laboratory.

Proximate composition analyses

Moisture, ash, crude fibre, protein and fat contents were determined using the methods of AOAC and the reducing sugar was determined by the method of [14,15].

Mineral composition analyses

Ca, Mg, Fe, Zn, Mn, Al, Pb and Cu contents were determined using the AAS (Atomic Absorption Spectrometer) by the procedure of AOAC, Na and K contents were determined by flame photometer (AOAC) and phosphorus content was by colorimetric method of AOAC [14].

Amino acid composition analyses

The amino acid profile (arginine, histidine, lysine, tryptophan, phenylalanine, methionine, threonine, leucine and valine) contents were determined by the method of Uysal, *et al.* [16].

Anti-nutritional composition analyses

Total oxalate, phytate, tannin, alkaloid, lignin, saponin and hydrogen cyanide contents were determined. Total oxalate content was determined by the method of AOAC, phytate content was determined by the spectrophotometric method as described by Agoreyo, *et al.* tannin content was determined by the spectrophotometric method of Jaffe, alkaloid content was determined by the method of Onwuka, lignin content was determined by the method of Morrison, *et al.* saponin content was determined by the method of Abhishek, *et al.* and hydrogen cyanide content was determined by the alkaline titration method of AOAC [14,17-21].

Data analysis

The results were presented as mean ± standard deviation of triplicate values. A one way analysis of variance (ANOVA) and Duncan Multiple Range test were carried out. Significant difference was accepted at 5% probability [22].

Results

The proximate composition of the sweet and bitter cassava varieties is presented in Table 1. The moisture content of the sweet cassava variety (8.04±0.74%) was significantly higher ($p<0.05$) than that of the bitter cassava variety (7.23±0.39%). The crude protein contents were 23.51±0.50% and 22.74±0.16% for the sweet and bitter cassava varieties respectively. Fat content was higher at 10.01±0.02% for the sweet cassava variety than the bitter cassava variety at 9.54±0.01%. Crude fibre and ash recorded 5.66±0.02% and 0.44±0.10% for the sweet cassava variety as compared with 4.13±0.02% and 0.35±0.02% for the bitter cassava variety. Reducing sugar content from carbohydrate breakdown in the sweet cassava variety was lower (33.79±0.09%), though not significantly ($p>0.05$), than the bitter cassava variety at 37.04±0.09%. Na and K had lower values ($p>0.05$) for the sweet cassava variety at 259.64±1.66 mg/l and 319.87±2.75 mg/l when compared to the bitter cassava variety at 338.66±6.59 mg/l and 431.96±7.23 mg/l respectively (Table 2). Ca, Mg and P contents were 224.57±4.16 mg/l, 35.17±4.65 mg/l and 593.73±5.82 mg/l respectively for the sweet cassava variety and 187.53±5.19 mg/l, 28.67±1.62 mg/l and 402.37±5.83 mg/l respectively for the bitter cassava variety. Fe, Mn, Al and Pb contents were higher in the bitter cassava variety than in the sweet cassava variety. Zn and Cu were significantly higher in the sweet cassava variety (20.85±1.60 mg/l and 3.96±0.25 mg/l) than in the bitter cassava variety (16.84±1.74 mg/l and 3.71±0.07 mg/l). The amino acid profile of the sweet and bitter cassava varieties is shown in Table 3. The bitter cassava variety had lower values for all the amino acids analyzed than the sweet cassava variety. In Table 4 is shown the anti-nutritional composition of the sweet and bitter cassava varieties. All the anti-nutrients had higher values for the bitter cassava variety than the sweet cassava variety. Hydrogen cyanide content was 7.58±1.25 mg HCN/100g and 20.13±0.09 mgHCN/100g, oxalate content was 1.30±0.02 mg/100g and 3.27±0.04 mg/100g, for the sweet and bitter cassava varieties respectively. The concentration of phytate was highest in the cassava varieties with 53.7±0.81 mg/100g for the sweet cassava and 62.4±1.29 mg/100g for the bitter cassava. Alkaloid concentration was 0.27±0.02% and 0.32±0.04% for the sweet and bitter cassava varieties respectively. The values for lignin and saponin were significantly higher ($P<0.05$) in the sweet cassava variety than the bitter cassava variety.

Cassava Varieties		
Parameter (%)	**Sweet**	**Bitter**
Moisture	8.04±0.74^{b}	7.23±0.39^{a}
Crude Protein	23.51±0.50^{b}	22.74±0.16^{b}
Fat	10.01±0.02^{b}	9.54±0.01^{a}
Crude Fibre	5.66±0.02^{b}	4.13±0.02^{c}
Ash	0.44±0.10^{c}	0.35±0.02^{c}
Reducing sugar	33.79±0.09^{b}	37.04±0.09^{b}

Values are means ± standard deviation (n=3). Means in the same row for each variety with same superscript are not significantly different (P>0.05)
Table 1: Proximate composition of sweet and bitter cassava varieties

Cassava Varieties		
Parameters (mg/l)	**Sweet**	**Bitter**
Calcium (Ca)	224.57±4.16^{b}	187.53±5.19^{a}
Magnesium (Mg)	35.17±4.65^{b}	28.67±1.62^{b}
Sodium (Na)	259.64±1.66^{c}	338.66±6.59^{c}
Potassium (K)	319.87±2.75^{c}	413.96±7.23^{c}
Phosphorus (P)	593.73±5.82^{a}	402.37±5.83^{a}
Iron (Fe)	75.49±.72^{b}	124.55±2.34^{b}
Zinc (Zn)	20.85±1.60^{b}	16.84±1.74^{a}
Manganese (Mn)	3.31±0.09^{d}	3.97±0.15^{c}
Aluminium (Al)	1.78±0.20^{b}	2.04±0.15^{a}
Lead (Pb)	0.83±0.10^{b}	1.05±0.24^{b}
Copper (Cu)	3.96±0.25^{a}	3.71±0.07^{b}

Values are means ± standard deviation (n = 3); means in the same row for each variety with same superscript are not significantly different (P>0.05)
Table 2: Mineral composition of sweet and bitter cassava varieties

Cassava Varieties		
Parameter (g/100g)	**Sweet**	**Bitter**
Arginine	12.75±0.48^{a}	8.27±0.14^{a}
Histidine	3.57±1.07^{a}	1.87±0.42^{c}
Lysine	4.15±0.20^{a}	1.85±0.06^{a}
Tryptophan	1.73±0.00^{a}	0.92±0.06^{a}
Phenylalanine	2.15±0.13^{a}	1.72±0.01^{a}
Methionine	2.39±0.05^{a}	1.97±0.06^{b}
Threonine	5.11±2.09^{a}	4.24±0.70^{c}
Leucine	18.70±5.08^{a}	16.71±2.19^{a}
Valine	13.90±7.76^{a}	8.72±0.31^{a}

Values are means ± standard deviation (n = 3); means in the same row for each variety with same superscript are not significantly different (P>0.05)
Table 3: Amino acid profile of sweet and bitter cassava varieties

Cassava Varieties		
Parameter	**Sweet**	**Bitter**
Hydrogen Cyanide (mgHCN/100g)	7.58±1.25^{a}	20.13±0.09^{a}
Oxalate (mg/100g)	1.30±0.02^{c}	3.27±0.04^{c}
Tannin (%)	0.2±0.01^{a}	0.3±0.00^{b}
Phytate (mg/100g)	53.7±0.81^{c}	62.4±1.29^{a}
Alkaloid (%)	0.27±0.02^{a}	0.32±0.04^{a}
Lignin (mg/100g)	0.13±0.01^{b}	0.18±0.01^{a}
Saponin (%)	0.13±0.01^{b}	0.21±0.01^{a}

Values are means ± standard deviation (n = 3); means in the same row for each variety with same superscript are not significantly different (P>0.05)
Table 4: Antinutritional composition of sweet and bitter cassava varieties

Discussion

The higher moisture, crude protein, fat, crude fibre and ash contents of the sweet cassava variety than the bitter cassava indicates that the sweet cassava variety is a better source of lipid, nitrogenous compounds and cellulose than the bitter cassava variety. This is in agreement with the study of Sarkiyayi and Agar [13] who reported higher moisture, ash, lipid contents in sweet cassava variety than bitter cassava variety. Since ash content is a measure of the total minerals present within a food, a reduction in its level is as a result of the minerals being used by the microorganisms during fermentation [23]. The reduction of the carbohydrate content of the cassava varieties to reducing sugar was due to the production of hydrolytic enzymes by the microbial flora present which they used as carbon source and transformed them to other macromolecules or metabolites such as protein and fat [4]. The reducing sugar content reduced as fermentation progressed. Panda, *et al.* demonstrated that *Lactobacillus plantarum* could produce α – amylase and reducing sugars from hydrolyzed starch and convert them into energy for their growth hence the carbohydrate was degraded faster to reducing sugar in the sweet cassava variety [24].

The evaluation of minerals in cassava is an important exercise from nutritional to the toxicological point of view [25]. This is because some of the metals have long term effects on human health when accumulated in target organs. The higher Ca, Mg, P, Zn and Cu contents in the sweet cassava variety than the bitter cassava is comparable with the study of Oboh and Elusiyan [5]. Metal deficiency syndrome like rickets and calcification of bones is caused by calcium deficiency [26]. Magnesium deficiency in man is responsible for severe diarrhea, migranes, hypertension, cardiomyopathy, arteriosclerosis and stroke [27]. It plays fundamental roles in most reactions involving phosphate transfer [28]. Phosphorus is involved in the intermediary metabolism of carbohydrates and it is a pre-requisite for bone and teeth structures [29]. Zinc is necessary for protein and nucleic acid synthesis and normal body development. The higher Zn content in the sweet cassava variety could be attributed to the reduced phytate content [5]. According to Reddy and Love, copper is needed for growth, production of bones, teeth, hair, blood, nerves, skin, vitamins and hormones. The concentrations of Na, K, Mn, Al, Fe and Pb were higher ($P>0.05$) in the bitter cassava variety than the sweet cassava variety in agreement with the study of Oboh and Elusiyan [5,30]. Sodium salts which are soluble in aqueous phase play important roles in transportation of metabolites in the body. Potassium takes part in ionic balance and tissue excitability. The low concentration of some of the micro elements was similar to that reported by Cardoso, *et al.* [31]. This could be due to the use of organic fertilizers by the local cassava farmers.

Amino acids serve as substrates for protein synthesis and play other roles as tissue repairs, hormone synthesis and precursors of heme as well as synthesis of enzymes that catalyze biochemical reactions in cells [32]. This study showed higher amino acid contents in the sweet cassava variety than the bitter cassava variety in comparison with the study of Aro and Aletor [33]. The presence of these eight essential and one non-essential amino acids in the cassava varieties would enhance its nutritive value with respect to its protein content and as well as releasing other materials exclusively in the consumed garri [34].

The anti-nutritional compositions of the cassava after fermentation agreed with the study of Oboh and Oladunmoye [35]. These anti-nutrients are used by the plant probably for defense [36]. The lower concentration of antinutrients in the sweet cassava variety corroborated with the study of Aro, *et al.* on cassava starch residues. Cyanide is poisonous because it binds with cytochrome oxidase and stops its action in respiration in the body [37]. The concentration of hydrogen cyanide in the fermented cassava varieties is lower that the lethal dose of between 30 and 210 mgHCN/100g [5]. Oxalic acid and its salts occur as end products of metabolism in a number of plant tissues. Oxalates can bind to calcium and other metals rendering these metals unavailable for normal physiological and biochemical roles such as maintenance of strong bones, teeth and nerve transmission [38]. Tannin affects nutritive value of food forming complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption [36]. The tannin content in this study was below the detrimental dose of 0.7–0.9%. Phytate is capable of chelating divalent cationic minerals like calcium, iron, magnesium and zinc thereby inducing dietary deficiency [39]. The phytate content of the fermented cassava varieties in this study was far below that of cassava flour in the study of Oboh and Elusiyan [5]. Wise suggested that the solubility of phytate and proportion of minerals bound to the complex depend on dietary calcium levels [40]. The high calcium levels could be attributed to the low phytate content in this study. The alkaloid content for both cassava varieties was comparable with that of cassava starch residues in the study of Aro, *et al.* [37]. Though alkaloids comprise a large group of nitrogenous compounds widely used as cancer chemotherapeutic agents, they interfere with cell division and almost uniformly invoke bitter taste in foods [41].

Lowering the size of cassava favours lignin degradation [42]. The low lignin content in this study indicated breakdown action by microorganisms during the fermentation process [43]. Saponins are phytonutrients found in particular abundance in various plant species are grouped by the soap-like foaming they produce when shaken in aqueous solution. Saponins when present in large amounts impart bitter taste to plant food and induce haemolysis and cholesterol binding [44]. These anti-nutrients form complexes with metals. The lower concentration of the anti-nutients in the sweet cassava variety than the bitter cassava variety may enhance absorption when they form complexes with these metals.

Conclusion

The processing of the cassava varieties into garri by fermentation enhances micronutrient availability, improves nutritional value and aids in degrading anti-nutritional factors. The higher nutritional and lower anti-nutritional quality of the sweet cassava variety than the bitter cassava variety makes sweet cassava a better variety for garri production.

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