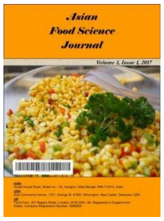

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Nutritional and Anti–Nutritional Evaluation of Garri Processed by Traditional and Instant Mechanical Methods

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Authors' contributions

This work was carried out in collaboration with all authors. Author AIA conceptualized and designed the study, and also wrote the manuscript. Author EOA managed the analyses of the study. Author OE managed the literature searches. Author EOO wrote the protocol while Author UO performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of this study is to evaluate the nutritional and anti-nutritional composition of garri processed by traditional and instant mechanical methods.
Place and Duration of Study: This study was carried out in Achara, Uturu and analyses were done at the Biochemistry and Central Laboratories of Gregory University, Uturu, Abia State between March and July, 2017.
Methods: Cassava was harvested and processed in Achara area of Uturu, Abia State. For garri processed by instant mechanical method, cassava was grated and dewatered using hydraulic press and were roasted (fried) within 24 hours of harvest. For garri processed by traditional

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method, the grated garri was allowed to stay for 24 hours in the sack before dewatering using sticks. The dewatering process took 3 days before roasting. The nutritional and anti-nutritional composition of raw cassava mash, garri processed by traditional and instant mechanical methods were evaluated using standard methods.

Results: The result of the analysis showed that garri processed by traditional method was higher in most of the nutritional factors but lower in all of the anti-nutritional factors investigated when compared with those of garri processed by instant mechanical method and raw cassava mash. Garri processed by traditional method was significantly higher in vitamin A but lower in vitamin C when compared with garri processed by instant mechanical method at $p<0.05$. Garri with palm oil has its cyanogenic glucoside significantly reduced when compared with garri without palm oil at $p<0.05$.

Conclusion: Long period of fermentation (3 – 5 days) of cassava product is recommended as garri processed by traditional method was nutritionally better than that processed by instant mechanical method due to the longer period of fermentation.

Keywords: Nutritional content; anti-nutritional content; garri processed by traditional method; garri processed by instant mechanical method; fermentation period.

1. INTRODUCTION

Cassava (*Manihot esculenta* Cranz) is a woody shrub native to South America of the spurge family, Euphorbiaceae [1]. It is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous root, a major source of carbohydrates [2]. Cassava is the third largest source of food carbohydrates in the tropics, after rice and maize. It is a major staple food in the developing world, providing a basic diet for over half a billion people [3]. It is one of the most drought-tolerant c rops, capable of growing on marginal soils. In 2014, global production of cassava root was 268 million tonnes, with Nigeria as the world's largest producer of nearly 55 million tonnes or 21% of the world total [4].

Cassava is classified as either sweet (*Manihot palmata*) or bitter (*Manihot esculenta* or *Manihot utilissima*). Like other roots and tubers, both bitter and sweet varieties of cassava contain anti-nutritional factors and toxins, with the bitter varieties containing much larger amounts [5]. It must be properly prepared before consumption, as improper preparation of cassava can leave enough residual cyanide to cause acute cyanide intoxication, goiters, and even ataxia, partial paralysis, or death [6]. The more toxic varieties of cassava are a fall-back resource (a "food security crop") in times of famine or food insecurity in some places. Farmers often prefer the bitter varieties because they deter pests, animals, and thieves [7].

In Nigeria, as in most African countries, cassava is one of the most important carbohydrate sources. About 95 percent of cassava is consumed as food and less than 5 percent of it is used for industrial purposes [8]. It is usually consumed in processed forms. In recent times, several processing options have emerged from cassava such as garri, fufu, starch, flour, tapioca and chips. Irrespective of these options, garri (roasted granules) and edible starch (which is a by-product from drying the grated tubers) have maintained an important position in the food timetable of many households in Nigeria and other countries of the world, although starch consumption is most notable in the south-south region of Nigeria [9].

Toxicity of cyanide in cassava products has been reported. There are as well few reported cases of death linked to consumption of cassava meals [10]. The incidents of cassava toxicity parallel severe hunger condition associated with drought or wartime when processors adopt “shortcut” (shortened process time) in order to meet market demand. Consumption of garri has always been a trend in Nigeria and some other parts of the world. The consumption of this product has been accompanied with some side effects like food poisoning and other related effects due to inefficiency in the course of production, which inevitably leads to improperly processed product, and when this product is consumed, it results to food poisoning and its effect can be fatal [10].

On 20th March 1994, one Mrs. Loveth Osueke was reported in the National dailies to have died after eating African Salad made from cassava which she bought from Ariaria market in Aba, Abia State, Nigeria. More recently, it was also reported in the national dailies on Tuesday 1st November, 2016 that six persons (including a mother, her three children and her two neighbours) died after consumption of cassava product ('lafun') in Ogaminana area of Okene in Kogi State, Nigeria [11].

Fermentation is an important processing technique for cassava, especially in Africa. Three major types of fermentation of cassava roots are recognized: the grated root fermentation, fermentation of roots under water and mould fermentation of roots in heaps [12]. The grated cassava roots are allowed to ferment in sacks for 3-7 days, which encourages lactic acid fermentation. The pH after 3 days decreases from 6 to 4 and the fermentation is dominated by lactic acid bacteria [5]. Grating is important for bringing linamarin into contact with linamarase allowing its hydrolysis to glucose and cyanohydrin and then to HCN [13]. The hydrolysis continues during the fermentation process. Lactic acid fermented products are reported to have significant concentrations of cyanohydrins because pH decreases during fermentation and cyanohydrin is stable at low pH. The processes of garri production reduce cyanogen contents by more than 95% [12]. Fermentation of cassava roots under water, followed by sun drying, is reported to be the best for cyanogens removal [14]. This type of fermentation is used more in areas where there is a sufficient supply of water such as near a river or lake, and is common in countries such as Nigeria, Democratic Republic of Congo, Tanzania and Malawi [12]. Heap fermented cassava root products are produced in Tanzania [15], Uganda and Mozambique [16]. The process involves peeling of cassava roots, sun drying for 1 to 3 days, heaping and covering, fermentation, scraping off the molds, crushing into crumbs, sun drying, pounding and sieving into flour. During the fermentation of the roots, the temperature inside the heaps increases between 23 and 29℃ higher than the temperature outside the heaps (2 to 12℃). According to Sani and Farahni, [16], heap fermentation is dominated by the *Neurospora sitophila, Geotrichum candidum* and *Rhizopus oryzae.* Heap fermentation of cassava roots followed by sun drying is capable of reducing the cyanogen levels by 95% [16].

2. MATERIALS AND METHODS

2.1 Production of Garri

Cassava was harvested and processed in Achara area of Uturu, Abia State. For garri processed by instant mechanical method, cassava was grated and dewatered using hydraulic press and were roasted (fried) within 24 hours of harvest. For garri processed by traditional method, the grated cassava mash was allowed to stay for 24 hours in the sack before dewatering using sticks. The dewatering process took 3 days before roasting. The two methods of processing were as described by Olukosi et al. [17].

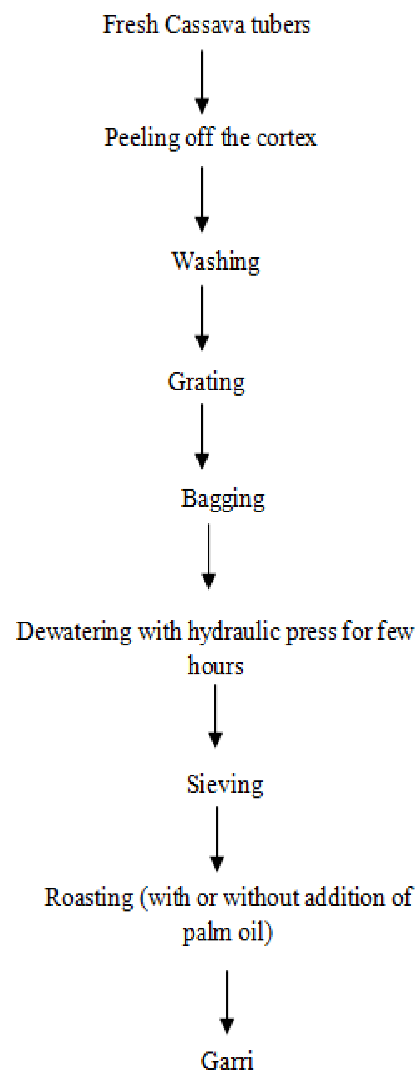

Fig. 1. Stages of processing Garri by instant mechanical method

2.2 Determination of Parameters

Nutritional and anti-nutritional analyses of raw cassava mash, garri processed by instant mechanical method and garri processed by traditional were carried out according to the methods described by AOAC [18]. Vitamin A content was determined as beta-carotene spectrophotometrically using the low volume hexane extraction method described by Fish et al. [19] while the vitamin C content was determined using the method of Benderitter et al. [20].

2.3 Statistical Analysis

Data were subjected to analysis of variance using the Statistical Package for Social Sciences (SPSS), version 20.0. Results were presented as Mean ± Standard Error of the mean (SEM). 2–tailed t–test was used for comparison of the means. Differences between means was considered to be significant at $p<0.05$.

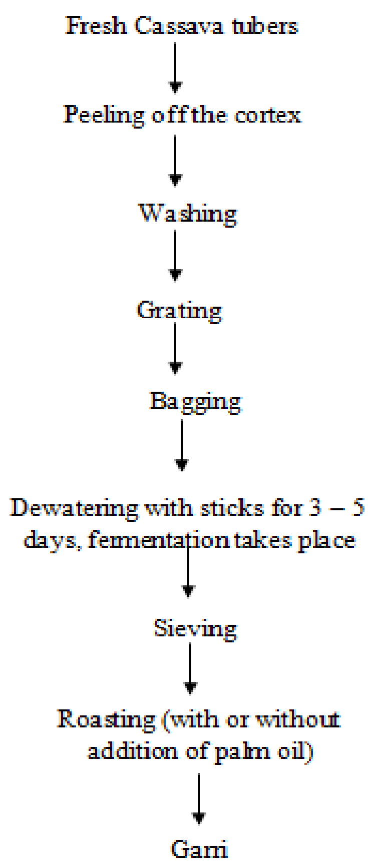

Fig. 2. Stages of processing Garri by traditional method

3. RESULTS AND DISCUSSION

Cassava (*Manihot esculenta* Crantz) and its products have been widely studied and reported to have beneficial effect, and sometimes with toxic effects [21]. Most of these effects are due to the presence of some non-nutrient factors in them. Cassava is a staple food in human diets in over 80 countries [21]. Starch, a product of cassava tubers is one of the most popular staple foods of the people of the rain forest belt of West Africa and contains mainly starch-20% amylase and 70% amylopectin having lost the soluble carbohydrates (i.e. glucose and sugar) during processing. Cassava can be processed into different products such as garri, tapioca, Africa salad, 'lafun' etc., the most common being garri. Cassava products are used as a primary staple food; careful processing to remove these toxic constituents is required to avoid chronic cyanide intoxication [22]. This study focuses on the evaluation of the nutritional and anti-nutritional composition of garri processed by the traditional method and those processed by the instant mechanical method.

The proximate composition of garri samples is shown in Table 1. Moisture content estimates directly the water content and indirectly the dry matter content of the sample. It is also an index of storage stability of the flour samples. Substances with moisture content less than 14 % can resist microbial growth and thus have better storability [23]. In this study, a significant decrease was observed in the moisture content of garri samples when compared to that of raw cassava mash at $p<0.05$. This is due to the fact that the processing of garri in both methods involves dewatering. Most of the water in the garri samples has been removed in this process.

Conversely, no significant difference was observed when the moisture content of garri processed by traditional method was compared with that processed by instant mechanical method. This is in agreement with the work done by Irtwange and Achimba [24] who studied the effect of the duration of fermentation on the quality of garri. Moisture removal in garri is a function of many factors such as temperature, time, humidity, etc. The available moisture in garri solely depends on the degree of dryness during frying. Generally, a well dried garri stores well as there would be no free moisture to encourage microorganisms multiplication in garri which otherwise would have had adverse effect on the quality.

The crude fibre (2.35 – 2.77%) of the garri samples were close to the range (2-3%) of crude fiber recommended for garri [25]. A significant decrease was observed when the fibre content of

Table 1. Proximate composition of Garri samples (%)

Parameters	Raw cassava mash	Instant mechanical Garri	Traditional Garri
Moisture	6.16 ± 0.21^{a}	4.04 ± 0.06^{b}	4.22 ± 0.12^{b}
Crude Fibre	3.81 ± 0.25^{a}	2.35 ± 0.02^{b}	2.77 ± 0.05^{b}
Ash	2.00 ± 0.10^{a}	1.91 ± 0.12^{ab}	1.78 ± 0.13^{b}
Crude Fat	2.27 ± 0.05^{a}	3.86 ± 0.02^{b}	4.69 ± 0.04^{c}
Crude Protein	2.14 ± 0.06^{a}	3.93 ± 0.02^{b}	5.08 ± 0.15^{c}
Carbohydrate	83.64 ± 2.90^{a}	83.92 ± 1.63^{a}	81.43 ± 1.97^{a}

Values are presented as Mean±S.E.M, n =3. Values with different superscript along the same row are significantly different at p<0.05

Table 2. Composition of Vitamins A and C in Garri samples

Vitamins	Raw cassava mash	Instant mechanical garri	Traditional garri
Vitamin A (μg/g)	0.92 ± 0.08^{a}	0.37 ± 0.04^{b}	0.57 ± 0.05^{c}
Vitamin C (mgAAE/mg)	23.27 ± 0.99^{a}	35.43 ± 2.82^{b}	28.28 ± 2.02^{c}

Values are presented as Mean±S.E.M, n = 3. Values with different superscript along the same row are significantly different at p<0.05

garri samples were compared with that of raw cassava mash at p<0.05. This might be due to the fact that the processing of garri in both methods involved sieving. Most of the fibres in the garri samples have been removed in this process. However, an insignificant increase was observed when the fibre content of garri processed by traditional method was compared with that processed by instant mechanical method. This is in agreement with the report of Bolarinwa et al. [26] who studied the effect of processing on beta-carotene content and other quality attributes of cassava flakes (garri) produced from yellow cassava varieties. Crude fibre has been reported to aid digestion of food through peristalsis movement of the bowel [25]. This indicates that garri processed by traditional method might be digested easily when compared with that processed by instant mechanical method and will not cause constipation.

In this study, a significant decrease was observed in the ash content of garri processed by traditional method when compared with that of raw cassava mash at p<0.05. The decrease was however not significant when compared to that of garri processed by instant mechanical method. Since ash content is a measure of the total minerals present within a food, a reduction in its level might be as a result of the minerals being used by the microorganisms during fermentation [27].

In this study, it was observed that the fat content of garri processed by tradition method was significantly higher than that in garri processed by instant mechanical method at p<0.05. This corresponds to the work done by Irtwange and Achimba [24] who studied the effect of the duration of fermentation on the quality of garri. The decrease in crude fat could be attributed to the rising temperature of fermentation. As the duration of fermentation increases, the temperature also increases [28]. Temperature is known to have an effect on physical characteristics of food fats. Weiss [29] has established that as temperature increases, the solid fat index of certain foods decreases. Temperature could probably be the reason for the rate of decrease of crude fat in garri during fermentation. Garri samples with low fat content will not undergo rancidity during storage. This indicates that garri processed by traditional method could be stored for longer period without any discolouration or development of off-odour when compared with that processed by instant mechanical method.

Fermentation of cassava improved the utilisation of the diets, measured as protein efficiency ratio and biological value [30]. The crude protein content of raw cassava mash, garri processed by instant mechanical method and garri processed by traditional method are 2.14, 3.93 and 5.08% respectively. The protein content increased significantly with fermentation. This might be mainly due to the reproduction of micro-organisms and their metabolic activity during fermentation, as reported by previous studies [31,32]. Enzymatic proteins are produced by the lactic bacteria that represent the dominant microflora. They hydrolyze the starch of the composite leading to the production of sugar, lactic acids, acetaldehyde, diacetyl, peptides, and amino acids, which are precursors of flavor [33].

A decrease in the carbohydrate level observed in garri processed by traditional method when compared to garri processed by instant mechanical method was due to fermentation. This might be 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 [34]. Increase in alpha-amylase activity during fermentation has been reported [35]. The alpha-amylase breaks down complex carbohydrates to simple sugar. Panda *et al*. [36] 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 in their study.

Vitamin A content of garri samples were determined as beta-carotene and are presented in Table 2. Once ingested, beta-carotene is converted to vitamin A in the body [35]. In this study, a significant decrease was observed in the beta-carotene content of garri samples when compared with that of raw cassava mash at $p<0.05$. Similarly, the beta-carotene content of garri processed by traditional method was significantly higher than that in garri processed by instant mechanical method. This corresponds with the report of Bolarinwa et al. [26] who studied the effect of processing on beta-carotene content and other quality attributes of cassava flakes (garri) produced from yellow cassava varieties. Generally, traditional method retained the beta-carotene content of the garri better than the instant mechanical method. This could be because leaching of beta-carotene was minimal during traditional processing due to less pressure applied to the cassava mash during dewatering [26].

Ascorbic acid is an effective quencher of singlet oxygen and other radicals. It has a vitamin E sparing antioxidant action, coupling lipophilic and hydrophilic reactions [37]. It reacts with superoxide and a proton to yield hydrogen peroxide or with the hydroxyl radical to yield water. It also enhances absorption of inorganic iron and inhibits the formation of nitrosamines in the stomach [38]. In this study, it was observed that fermentation caused a significant increase in the ascorbic acid content of garri processed by instant mechanical method when compared with that of raw cassava mash at $p<0.05$. This increase in the ascorbic acid content by fermentation is consistent with the report of other investigators. It has been reported that vitamin C content of citrus peels and white cabbage increased with fermentation [39,40]. Adetuyi and Ibrahim [41] also reported an increase in vitamin C content when okro seeds were fermented for 24 hours. On the contrary, different authors have found that fermentation processes caused noticeable reductions in vitamin C content of *Vigna sinensis* and *Lupinus albus* [42,43]. It was observed in this study that as the fermentation time increased, ascorbic acid content of garri decreased. This is shown as a significant decrease was observed in the ascorbic acid content of garri processed by traditional method when compared with that of garri processed by instant mechanical method. This in agreement with the work of Adetuyi and Ibrahim [41] who reported an increase in vitamin C content when okro seeds were fermented for 24 hours but the vitamin C content however decreased with increased duration of fermentation. The decrease in vitamin C content observed in garri processed by traditional method may be as a result of the increase in the activity of the enzyme, ascorbate oxidase that might have been produced by the fermentation microorganism which strongly depends on the pH of the fermentation environment. The enzymes convert ascorbic acid to dehydroascorbic acid [44].

In this study, there was a general noticeable reduction in the entire anti-nutrient constituents quantified for in the garri samples. This could be attributed to the activities of the indigenous microbes as well as processing methods which could initiate the activities of some indigenous enzyme that degrade these anti-nutrients during fermentation [45]. It should be noted that the anti-nutrient constituents could be influenced by the type of cassava, soil condition, the age/maturity of the roots, the time and the prevailing relative humidity during the harvesting and processing of the roots [46]. All the garri samples used in this study were harvested from the same farm. The anti-nutritional composition of the garri samples are presented in Table 3. These anti-nutrients are used by the plant probably for defense [30]. The lower concentration of anti-nutrients in the garri processed by traditional method

Table 3. Anti–nutritional composition of garri samples

Anti-nutrients	Raw cassava mash	Instant mechanical garri	Traditional garri
Phytate (g/100g)	17.61 ± 0.80^a	15.25 ± 0.39^b	13.11 ± 0.89^c
Alkaloid (g/100g)	0.33 ± 0.04^a	0.31 ± 0.03^a	0.29 ± 0.06^a
Oxalate (g/100g)	1.13 ± 0.12^a	1.12 ± 0.04^a	1.11 ± 0.02^a
Saponin (g/100g)	0.22 ± 0.03^a	0.15 ± 0.02^b	0.09 ± 0.02^b
Flavonoid (g/100g)	6.16 ± 0.44^a	5.19 ± 0.39^a	3.17 ± 0.71^b
Lignin (g/100g)	0.18 ± 0.02^a	0.15 ± 0.02^{ab}	0.13 ± 0.02^b
Tannin (g/100g)	0.37 ± 0.02^a	0.30 ± 0.02^b	0.22 ± 0.04^b
Cyanide (μg/g)	32.00 ± 1.67^a	21.07 ± 1.68^b	8.15 ± 0.44^c

Values are presented as Mean±S.E.M, n =3. Values with different superscript along the same row are significantly different at p<0.05

corroborated with the study of Aro et al. [47] on cassava starch residues and that of Oboh and Oladunmoye [48].

In this study, a significant decrease was observed in the phytate content of garri processed by traditional method when compared with those of raw cassava mash and garri processed by instant mechanical method respectively at $p<0.05$. This corresponds to the findings of Oboh and Elusiyan [49] in determining the phytate content of fermented cassava varieties. Knowledge of phytate levels in food is necessary because a high content can cause harmful effects on digestibility [50]. Phytate has been recognized as an anti-nutrient due to its adverse effects. It reduced the bioavailability of minerals and caused growth inhibition. Phytate is capable of chelating divalent cationic minerals like calcium, iron, magnesium and zinc thereby inducing dietary deficiency [51,52]. Wise [53] suggested that the solubility of phytate and proportion of minerals bound to the complex depend on dietary calcium levels.

The reduction observed in the alkaloid, oxalate, saponin, flavonoid, lignin and tannin contents in garri processed by traditional method when compared to that of garri processed by instant mechanical method corresponds to the report of Bolarinwa et al. [26] who studied the effect of processing on beta-carotene content and other quality attributes of cassava flakes (garri) produced from yellow cassava varieties. 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 [54]. 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 [55]. The low lignin content in garri processed by traditional method indicated breakdown action by microorganisms during the fermentation process [56]. Saponins are phytonutrients found in particular abundance in various plant species and 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 [57]. Flavonoid has been reported to be an important phytochemical due to its antioxidant properties [58]. Some plants have been reported to prevent ulcer due to their flavonoid content [59,60,61]. The consumption of food high in tannin can cause oesophageal cancer [62]. Tannins have been reported to form complexes with proteins and reduce their digestibility and palatability [63]. They also bind iron, making it unavailable [64]. However, tannins are water soluble compounds and as such can be eliminated by soaking followed by cooking [65]. The tannin content in both garri samples were below the detrimental dose of 0.7–0.9%. These anti-nutrients form complexes with metals. The lower concentration of the anti-nutrients in garri processed by traditional method may enhance absorption when they form complexes with these metals.

In this study, a significant decrease was observed in the cyanogenic glucoside of garri processed by traditional method when compared with that of garri processed by instant mechanical method and raw cassava mash respectively at $p<0.05$. This could be attested to by the report of Endris [66] who stated that there is a proportional reduction of residual hydrocyanic acid in garri samples from 0 to 96 hours of processing. This could be as a result of several reasons: Firstly, the grating of the peeled cassava roots/tubers to obtain the mash disrupts the structural integrity of plant cells, thus allowing the cyanogenic glucosides from storage vacuoles to come in contact with the enzyme linamarase on the cell wall [67]. When plant tissues are crushed (mashed roots), the plant cell structure may be so damaged that the enzymes can meet with and act on the cyanogenic glucoside [67]. The action of linamarase on linamarin and lotaustralin is the hydrolytic release of acetone cyanohydrin and butan-2-one which is unstable. At pH above 5, they spontaneously decompose to the corresponding ketone and HCN which is lost by volatilization [67]. As the fermentation time increases, the decomposition of cyanide to the corresponding ketone and HCN also increases, thereby reducing the cyanide left. The second reason could be the high temperature at which garri was roasted and dried. The heat resulting from high temperature reduced the HCN content of the garri. This is in agreement with the observation of Meuser and Smolnik [68] on the effect of heat on hydro-cyanic acid content. Cyanide is poisonous because it binds with cytochrome oxidase and stops its action in respiration in the body.

The HCN levels in garri processed by both traditional and instant mechanical methods used in this study are 8.15 and 21.07 µg/g respectively on dry matter basis. A value of < 50 µg/g has been regarded as acceptable level of cyanide in garri [69]. However, long-term consumption of garri containing low levels of HCN produces goiter and neuropathy and 50 mg of cyanide per 50 kg body weight could be lethal to man [70]. This implies that an average person of 70 kg body weight will have to consume between about 53 to 1944 kg dry garri flour before the lethal effects of cyanide poisoning will set in. The short-cut method of production of garri (as in the case of instant mechanical method) results in incomplete hydrolysis of acetone cyanohydrins [71]. Thus acetone cyanohydrins is the major cyanogen found in insufficiently detoxified garri flour [72] and are hydrolyzed rapidly to poisonous hydrogen cyanides on consumption, due to high pH of human gut into acetone and poisonous cyanides [73]. Prolonged high dietary exposures to cyanogen have been implicated in various diseases such as tropical ataxic neuropathy, goiter and konzo in population with monotonous cassava meal consumption [74,75]. The increasing incidences of cyanides related complications like dizziness; headache, blindness, deafness, abdominal pains, vomiting, diarrhea and unsteady walking observed in people especially among the poor rural elderly population might be an upshot of high dietary exposure to unhydrolyzed acetone cyanohydrins in garri and other cassava products. These metabolic disorders are most often associated with interplay of supernatural forces or divine punishment or sorcery in Africa [76]. Its specific prevalence among the older and rural poor with monotonous diet of cassava diets, may be explained by the fact that, rhodanase an enzyme located in all tissues, but mainly in the liver performs the function of detoxification and transformation of cyanides to thiocyanate before urine excretion. The process requires sulphur donors, provided by a corresponding dietary rich source of protein, which are lacking in cassava diets [77,78]. Moreover, as aging process progresses, the liver ability to secrets rhodanase reduces, causing cyanides level in the blood to increase; this explains the preponderance of the resulting metabolic disorders amid the aging population. Since the longer the fermentation period the less the residual cyanide content of the final garri product, it is necessary to discourage, for toxicological reasons, the common practice by many garri processors of reducing fermentation period of cassava mash from three days in an attempt to increase turnover rate.

The effect of addition of palm oil on the cyanide content of garri samples was also investigated in this study. It was observed that white garri (garri without palm oil) had significantly higher levels of residual HCN than the yellow garri (garri with palm oil) for raw cassava mash, garri processed by instant mechanical method and garri processed by traditional method respectively (Table 4). These differences were found to be statistically significant as determined by t-test at $p<0.05$. Various reasons have been advanced for the reduced HCN level in yellow garri. The time of addition of palm oil to the grated cassava during processing, i.e., prior to fermentation or during roasting had little or no influence on the HCN content of the produced garri flour. The rate of hydrolysis of cyanogenic glucoside in cassava to produce the poisonous hydrogen cyanide is affected by the addition of palm oil in garri [79]. However, the low level of cyanide in palm oil garri flour could be related to the sequestration of CN^- by palm oil components into a complex and therefore unavailable for quantitative measurement. Cardoso et al. [80] reported that palm oil delays the decomposition of the cyanogenic glycosides. This could be responsible for the low concentration of hydrocyanic acid in the yellow garri. Again, palm

Table 4.The effect of palm oil on the cyanogenic glucoside of garri

	Cyanogenic glucoside of raw cassava mash (μg/g)	Cyanogenic glucoside of instant mechanical Garri (μg/g)	Cyanogenic glucoside of traditional garri (μg/g)
Without Palm Oil	32.00 ± 1.67^{a}	21.07 ± 1.68^{a}	8.15 ± 0.44^{a}
With Palm Oil	22.26 ± 1.45^{b}	12.01 ± 0.74^{b}	3.82 ± 0.93^{b}

Values are presented as Mean±S.E.M, n =3. Values with different superscript along the same column are significantly different at p<0.05

oil has been reported to contain sulphur-containing amino acids which bind HCN forming thiocyanide thereby reducing the cyanide level in the garri containing palm oil.

All these anti-nutritional constituents in garri processed by both traditional and instant mechanical methods were found below the acceptable level which shows that the samples were safe for consumption. This result is consistent with the findings of Bamidele et al. [81].

4. CONCLUSION

Long period of fermentation (3 – 5 days) of cassava products is recommended as garri processed by traditional method was nutritionally better and with less cyanogenic glucoside content than that processed by instant mechanical method due to the longer period of fermentation. Similarly, addition of palm oil during processing also reduced the cyanogenic glucoside of garri samples in this study. Processors of garri should be enlightened on the dangers of garri high in cyanide to human health and should be encouraged to avoid short-cut practice in the production of garri. Garri should be allowed to ferment for at least 72 hours before roasting.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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