Effect of processing methods and fermentation period on the residual content of hydrogen cyanide in Garri

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Abstract: The effect of processing methods and fermentation period on the residual content of Hydrogen Cyanide was investigated in garri produced from locally grated and machine crushed cassava tubers with fermentation periods of 12, 24, 48 and 72 hours respectively. The result of proximate composition showed that moisture content ranged between 3.90 – 6.55%, protein 5.00 – 6.99%, fat 4.04 – 8.43%, crude fibre 3.04 – 5.83%, Ash content 2.05 – 3.02%, carbohydrate 78.82 – 84.11% and energy 411.15 – 391.92 k/cal. Result of the functional properties of the samples showed that bulk density varied between 0.49 – 0.77 (g1cm3), oil absorption 0.71 -2.32 (ml/g), water absorption 4.01-4.77 (ml/g), swelling capacity varied between 1.84 -3.63 (vol/ml). Generally, there was significant difference among all the samples analysed ($p<0.5$). Sensory evaluation studies showed preference for the garri produced from locally grated cassava fermented for 12 hours (A) in terms of general acceptability while the locally grated but fermented for 48 hours (E) was preferred in terms of texture and appearance. Using a nine point hedonic scale, all the samples were accepted though sample A was rated best. Hydrogen cyanide content in all the sample ranged between 3.11 – 15.95 (mg/kg HCN); oxalate 1.13 – 8.10 (m/kg), Tannin 0.11 -3.07 (mg/kg). Garri sample processed and fermented for 12 hours had concentration of hydrogen cyanide (15.24 -15.95 mg/kg HCN) higher than tolerable limits (10 -15mg/kg HCN) as stipulated by NAFDAC in Nigeria.
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Key words: Cassava, Garri, Hydrogen cyanide, fermentation, processing

Introduction

Cassava is a major food crop supplying about 70% of the daily calories of over 50 million people in Nigeria (Oluwole *et al.,* 2004). At 93 million tons, cassava accounted as a major food in tropical Africa in 1996 (Scott *et al.,* 2000). It has also been estimated that cassava provides food for over 500 million people in the world (Abu *et al.,* 2006; Afoakwa *et al.,* 2010; FAO, 2011). Edible part of freshly harvested cassava root contains 32:35% of carbohydrate, 3.2% protein, 75 -80% moisture, 0.1 fat, 1.0% fiber and 0.70 – 2.50% Ash (Oluwole *et al.,* 2004). More than any other crop in Africa, cassava has assumed great importance in African agriculture and food supply. The reason for this is because of the following features which cassava posses:

- Cassava is highly adaptable to a wide Agro-ecological conditions and gives relatively high yields even on poor soils.
- Cassava has no fixed planting and harvesting time and its projunction require relatively low skill.
- Cassava is relatively tolerant to pest which devastates other crops easily.

A wide variety of foods are produced from cassava by fermentation, viz Garri, fufu, flour, starch to mention a few (Adesina, 2001). Cassava plants are of two major types namely: sweet cassava (Manihot utilisina) which contains appreciable low cyanide content and bitter cassava (Manihot palmate) with very high level of cyanide. There are over thirty different cassava cultivars in Nigeria with various levels of cyanide content (Achinewhu *et al.,* 1998).

The two major cyanogenic glucosides in cassava: Linamarin and Lotaustralin are hydrocyanic to produce hydrocamic or prussic acid, a poison, when it comes into contact with the enzyme limamarare (Marcus and Adesina, 2001).

Several authors have reported on the toxicity to cassava products with respect of cyanide content (Montgomery, 1969; Coursey, 1973; Maduagwu and Adewale, 1981 and Almazon, 1986).

Omoike and Adediran (1991) observed that there are several processing methods involved in the production of foods from cassava. Influenced by the level of residual cyanide in the product, fermentation is one of the traditional methods of reducing cyanide in garri with periods of about 5 to 6 days (FIIRO, 2006). Although steps such as peeling, washing, grating, drying, dewatering, milling and toasting can also influence the level of residual cyanide in cassava products (Omoike and Adediran, 1991).

Few comparative studies have been carried out on the effect of processing and fermentation period on cyanide reduction in cassava products, with the assumption that the commercially sold cassava product (garri) has a high level of residual cyanide

due to short fermentation period of the cassava pulp by the producers in a bid to increase turn-over and hence maximize profit (Odoemelam, 2005). This assumption represents a health risk since cassava consumption has been associated with several types of pathological disorders (Enidiok *et al.,* 2008). Cassava is by far the most cyanogenic food crop for humans and is an important source of dietary energy in tropical regions. Generally cassava may contain up to 1000 mg/kg HCN (Cooke, 2010).

Grating or crushing of cassava tubers exposes the cyanogens which are located in the cell vacuole to the enzyme located on the outer cell membrane, facilitating their hydrolysis.

Increase intake of cyanide in the diets or man can lead or contribute to goiter, cretinism, paralysis and neurological disorders. Different methods have been developed to improve on the processing of cassava roots resulting in less residual cyanide. Effective processing methods should disintegrate the root tissue completely thereby releasing an endogeneous enzyme linamarase. This endogeneous -glucosidase enables the hydrolysis of linamarin into glucose and acetone cyanohydrins. These chemical component will decompose above pH 6 into volatile hydrogen cyanide (HCN) that will be rapidly lost from the system during processing.

The critical steps generally required for the reduction of hydrogen cyanide to a safe level of consumption include: peeling, washing, grating, fermentation, garri – frying/toasting. However, the most efficient processing method is fermentation which does not only enhances detoxification but also improves the nutritional quality and hygienic safety of the garri (Oyewole and Isah, 2012).

This study aimed at consolidating knowledge on the effect of processing method and fermentation period on the residual content of hydrocyanic acid (HCN) in garri. It would also attempt to educate the producers (private and commercial) on the necessary guidelines in the production process of garri with permissible level of hydrogen cyanide (HCN).

Materials and Methods

Collection and Sample

Samples of matured cassava root (tubers) were purchased from the University of Uyo Farms, Nsukara Offot, Uyo, Nigeria.

Preparation of the Samples

The harvested cassava tubers were cleaned and sorted to remove contaminants in order to ensure wholesomeness of the samples before further processing. The cleaned and sorted cassava tubers were peeled and grated using two processing methods (locally grated and machine crushed).

The grated cassava pulp was packed in jutes bags, tied and allowed to ferment over a period of 12,24,48 and 72 hours respectively. This was accomplished by interval pressing of the cassava pulp.

For the machine crushed, jute bags were placed on the hydraulic press at intervals to remove excess water. The pressed cake from both was broken into pieces with hand and sieved with a wire mesh screen. The sieved pulp was fried using a wide shallow cast iron pan and stirred constantly over a low fire until well dried. The method of Sanni (2001) was used with slight modification. It was thereafter cooled, packaged, labeled and sealed.

Chemical Analysis

The chemical analysis of the garri samples were carried out to determine the following: moisture content, ash, crude fibre, crude protein, crude fat, carbohydrate (by difference), caloric value estimation, hydrocyanic acid, phytate, oxalate, tannin using the methods of AOAC (2005).

Determination of functional properties of garri samples

Bulk density was determined by the method described by Onwuka (2005), swelling capacity of the samples was determined using the method of Sanni *et al..,* (2001). Water and oil absorption capacities were also determined using the method of Onwuka (2005).

Sensory Evaluation

Sensory evaluation was conducted to determine consumer preferences and acceptability of the samples using 9-point hedonic scale of likeness. The samples were coded as: 210, 130, 820, 234, 182, 301, 194, 301. Quality parameters assessed were: appearance, texture flavor, mouth feel and overall acceptability. 9 represented “liked extremely” while 1 represented dislike extremely (Akinjayeju, 2001).

Statistical analysis

All treatments were replicated twice for reproducibility and analysis done in duplicate. Data were subjected to analysis of variance (ANOVA). The means were then separated by New Duncan Multiple Range Test (DMRT) using the Statistical Package for Social Sciences (SPSS) 20.0 software.

Discussion

From the result of the proximate analysis of samples in Table 4. It was observed that the method of grating and period of fermentation had significant effect ion the proximate composition. Moisture content was observed to be within the range of (3.90 – 5.53%) for the locally grated/fermented and (5.90 – 5.53%) for machine crushed/fermented. However, the moisture decreased as fermentation period increased. The available moisture in the sample solely depended on the degree of dryness during garri frying,

although values obtained were far lower than the recommended 13% for garri (FAO, 2006).

The difference observed here could be due to the method of grating and the period of fermentation. Irtwarge and Achimba (2009) reported that moisture removal in garri is a function of many factors such as temperature, time (duration) and humidity etc. Generally, a well dried garri stores well as there would be no free moisture to encourage microbial activity which would have had adverse effect in the quality of the garri (Bokanga, 1995). The ash content obtained ranged between (2.05 -3.06%) for locally grated/fermented and (2.05 -2.08)% for machine crushed/fermented. This also increased as the fermentation period increased with an indication of improvement in the mineral content of the sample. The crude protein ranged between (5.00 – 6.69%) for locally grated/fermented and (4.65 – 5.98%) for machine crushed/fermented. It appears that the protein content increased; as the fermentation period increased, sample for 12 hours of locally grated/fermented had 5.00% while 72 hours of fermentation had 6.69%.12 hours of machine crushed/fermented had 4.68% while 72 hours had 5.98%.

By implication the period of fermentation would have been responsible for the increase noticed in protein content which compared also with the report of Irtwange and Achimba, (2009) who reported that protein was within the range of 2.23% at 24 hours, 2.4% at 48 hour and 2.45% at 72 hours. The difference in the amount of protein from this experimental sample could be due to the variety of cassava tuber used.

Crude fat (Table 4.1) was significantly different from each sample ($p>0.05$). The increase in fat content could probably be due to the temperature of fermentation and frying. These findings agree with the reports of Ihekoronjere and Ngoddy, (1985); Ukpabi and Ndimele, (1990); Abokanga, (1995); FAO, (2005). The lower levels of fat obtained from these results could give a higher probability of a longer shelf-lye in terms of the onset of rancidity

Crude fibre decreased as the period of fermentation increased in both treatments. This findings however disagrees with the report of Bokonga (1995) who stated that fermentation of cassava (Garri) between 0- 5 days increased the fibre content. However, the findings of Oluwafemi and Udeh (2016) agrees with the result of this experiment. The result of the carbohydrate content in locally grated and fermented sample was within the range of (78 – 82 – 82.23%) while machine grated/fermented was (80.74 – 84.11%). Energy or caloric values of the garri samples were significantly different from each other. Energy levels obtained were within permissible levels as reported by Ihekoronge and Ngoddy (1985). Results of the functional properties is shown in Table 4.2. Bulk density did not increase after 12 and 24 hours for locally grated samples respectively. The same was observed for machine crushed/fermented. There was a step wise increase of bulk density in all the samples within the range reported by Andidu (2006). High bulk density implies reduction in volume and a larger quantity (weight) of garri can be packaged or transported per volume of space.

Water absorption result is also shown in Table 4.2. IE ranged between 4.01 – 4.61 ml/g for locally grated/fermented and 4.31-4.77 ml/g for machine crushed/fermented. Samples fermented for 72 hours had the highest water absorption capacity in both locally grated and machine crushed respectively. Heat intensity at which garri is fried affects its water absorption intake and further influence rehydration during reconstitution.

Table 4.2 also shows the oil absorption capacity for all the samples. There was significant different between the samples ($p> 0.05$). Higher values were obtained in samples at 72 hours fermentation. These findings compare with those of Chika *et al.,* (2013) and Oluwafemi and Udeh (2016). Swelling capacity (Table 4.2) of the samples was time and temperature dependent. Swelling capacity increased with increase in temperature and duration of fermentation. Swelling capacity is an indication of the water absorption index of the granules during heating (Ikegwu *et al.,* 2010). Moorthy and Ramamijam (1986) reported that the swelling capacity of granules reflected the extent of the associated forces with the garri granules.

Table 4.3 shows the result of the anti-nutritional composition of the garri samples. There was significant difference among the samples. It is possible that the grating of the peeled cassava to obtain the mash disrupted the structural integrity of the cells, thus allowing the cyanogenic glycosides from storage of vacuoles to come in contact with the enzyme linamarase on the cell wall (Bokanga, 1995). When plant tissues are crushed (mashed roots), the plants cell structure may be so damaged that the enzyme can meet with the act on the cyanogenic glycoside (Oluwole *et al.,* 2004, Oluwafemi and Udeh, 2016). The action of linamarin and lotastraulin is the hydrolytic release of acetone cyanohydrins and 2-butanone which is unstable. Fermentation period and grating method affected the level of hydrogen cyanide in the samples. The result showed higher content of hydrogen cyanide in samples with shorter fermentation period and vice versa. Meuser and Smolnit (1980), Bokanya (1995) and Oluyemi and Udeh, (2016) reported that grating, fermentation and

frying could cause volatilization of the hydrocyanic acid. Results of other antinutrient from this experiment were within limits reported by other authors and considered Safe (Bokanga, 1995, Charles and Hilary, 2005 and Obadina *et al.,* 2007.

Garri should be properly grated and fermented as both processes help in the reduction of anti-nutrients content of the product. Also heat generated during frying would have burned off greater part of the anti-nutrients in garri (Adidu *et al.,* 2003).

The results of the sensory attributes of the garri samples is shown in Table 4.4. There was no significant difference between the samples. However, in terms of colour, sample E was rated best followed by samples A, B, and C. The reason could be due to the slight non-enzymatic browning that occurred in sample E during frying with moderate heat intensity (Ekwu and Ugwuona, 2007).

Sample A was the overall best rated by the panelists while sample G was the least. The observed variations in the sensory attributes of the garri samples could be due to method of grating/fermentation period as well as frying.

Conclusion:

The findings from the study showed that processing (grating) methods and fermentation period affects the residual content of hydrogen cyanide as well as the nutritional composition of garri. Increase fermentation period will enhance garri product that is safe for consumption as it will reduce the amount of residual hydrogen cyanide content.

Table 1: Proximate Composition Of Garri Samples

Percentage Composition (%)							
Samples	**Moisture**	**Protein**	**Fat**	**Fibre**	**Ash**	**Cho**	**Energy**
LG12	5.53 ± 0.02^{b}	5.00 ± 0.03^{g}	8.43 ± 0.02^{a}	5.70 ± 0.02^{b}	2.05 ± 0.05^{c}	78.82 ± 0.02^{f}	411.15 ± 0.01^{a}
LG24	5.41 ± 0.01^{c}	5.10 ± 0.02^{f}	6.78 ± 0.02^{b}	3.80 ± 0.05^{f}	2.09 ± 0.01^{c}	82.23 ± 0.02^{c}	410.34 ± 0.02^{b}
LG 48	3.99 ± 0.01^{e}	5.77 ± 0.03^{c}	6.39 ± 0.01^{d}	3.04 ± 0.04^{g}	3.02 ± 0.02^{a}	81.78 ± 0.02^{d}	407.71 ± 0.01^{c}
LG72	3.90 ± 0.02^{f}	6.69 ± 0.01^{a}	5.43 ± 0.01^{e}	3.04 ± 0.02^{g}	3.06 ± 0.02^{a}	81.78 ± 0.01^{d}	402.75 ± 0.05^{e}
MC12	6.55 ± 0.01^{a}	4.68 ± 0.02^{h}	6.70 ± 0.03^{c}	5.83 ± 0.02^{a}	2.05 ± 0.05^{c}	80.74 ± 0.02^{e}	401.98 ± 0.02^{b}
MC 24	5.10 ± 0.05^{d}	5.25 ± 0.05^{e}	6.39 ± 0.01^{d}	4.49 ± 0.01^{c}	2.08 ± 0.02^{c}	81.79 ± 0.01^{d}	405.67 ± 0.03^{e}
MC48	5.07 ± 0.03^{d}	5.41 ± 0.01^{d}	4.10 ± 0.05^{f}	4.27 ± 0.03^{d}	2.11 ± 0.01^{c}	84.11 ± 0.01^{a}	394.98 ± 0.02^{g}
MC72	5.05 ± 0.05^{d}	5.98 ± 0.02^{b}	4.04 ± 90.04^{g}	4.00 ± 0.02^{e}	2.80 ± 0.04^{b}	82.91 ± 0.01^{b}	391.92 ± 0.02^{h}

Values are means ±SD of triplicate determination.

Means in the same column with different superscript are significantly different at ($p<0.05$).

Key:

CHO - Carbohydrate

LG12 -locally grated/fermented for 12 hrs
LG 24 locally grated/fermented for 24 hrs
LG 48 locally grated/fermented for 48 hrs
LG72 locally grated/fermented for 72 hrs

MC12 -machine crushed/fermented for 12 hrs
MC24 -machine crushed/fermented for 24 hrs
MC48-machine crushed/fermented for 48 hrs
MC72-machine crushed/fermented for 72 hrs.

Table 2 Functional Properties Of The Garri At Different Levels Of Treatments

Samples	**Bulk Density (Gkm^3)**	**Water Absorption (Ml/G)**	**Oil Absorption (Ml/G)**	**Swelling Capacity (Vol/Ml)**
LG12	0.63 ± 0.01^{c}	4.01 ± 0.00^{c}	1.71 ± 0.01^{h}	2.10 ± 0.01^{d}
MC12	0.63 ± 0.03^{c}	4.01 ± 0.00^{e}	1.07 ± 0.00^{g}	3.63 ± 0.00^{a}
LG24	0.68 ± 0.01^{c}	4.61 ± 0.00^{c}	0.60 ± 0.00^{e}	2.01 ± 0.01^{e}
MC24	0.64 ± 0.02^{b}	4.31 ± 0.02^{d}	1.42 ± 0.01^{f}	1.86 ± 0.01^{f}
LG48	0.49 ± 0.00^{d}	4.62 ± 0.02^{c}	1.88 ± 0.00^{e}	1.84 ± 0.00^{f}
MC48	0.62 ± 0.02^{c}	4.61 ± 0.00^{c}	1.79 ± 0.01^{d}	2.60 ± 0.00^{b}
LG72	0.65 ± 0.01^{c}	4.71 ± 0.02^{a}	2.32 ± 0.01^{a}	2.10 ± 0.00^{d}
MC72	0.77 ± 0.01^{a}	4.77 ± 0.01^{b}	1.24 ± 0.00^{b}	2.13 ± 0.03^{c}

Values are means ±SD of triplicate determination.

Means in the same column with different superscript are significantly different at ($p<0.05$).

Key:

LG12 - Locally grated/fermented for 12 hrs
MC12 - Machine crushes/fermented 12hrs
LG 24 - Locally grated/fermented for 24hrs
MC24 - Machine crushed/fermented for 24hrs
LG48 - Locally grated/fermented for 48 hrs
MC48 - Machine crushes fermented for 48hrs.
LG72 - Locally grated/fermented for 72hrs
MC72 - Machine crushed/fermented for 72hrs

Table 3 Anti-Nutritional Composition Of Garri Samples

Samples	HCN	Oxalate	Phytate	Tannin
LG12	15.24±0.02[b]	8.14±0.01[a]	3.42±0.01[a]	3.07±0.03[a]
LG24	10.16±0.02[d]	5.00±0.05[c]	2.63±0.02[b]	2.14±0.01[b]
LG48	4.04±0.01[f]	2.27±0.03[d]	1.30±0.05[c]	2.14±0.01[b]
LG72	3.11±0.01[h]	1.13±0.02[f]	0.61±0.01[e]	0.13±0.02[c]
MC12	15.95±0.05[a]	8.10±0.02[a]	3.45±0.02[a]	3.07±0.03[a]
MC24	11.28±0.02[c]	5.10±0.05[b]	1.21±0.02[d]	0.12±0.02[c]
MC48	5.60±0.03[e]	1.24±0.02[e]	0.10±0.02[f]	0.12±0.01[c]
MC72	3.32±0.02[g]	1.24±0.01[e]	0.09±0.10[f]	0.11±0.01[c]

Values are means ±SD of triplicate determination.
Means in the same column with different superscript are significantly different at ($p<0.05$).

Key:
HCN - Hydrogen cyanide
LG12 - Locally grated/fermented for 12 hrs
MC12 - Machine crushes/fermented 12hrs
LG 24 - Locally grated/fermented for 24hrs
MC24 - Machine crushed/fermented for 24hrs
LG48 - Locally grated/fermented for 48 hrs
MC48 - Machine crushed/fermented for 48hrs.
LG72 - Locally grated/fermented for 72hrs
MC72 - Machine crushed/fermented for 72hrs.

Table 4 Sensory Evaluations Of Garri Samples

Samples	Appearance	Texture	Flavor	Mouthfeel	General Accepta-Bility
A 210	7.10±1.25[a]	6.75±1.61[a]	6.70±1.55[a]	6.45±1.60[a]	7.05±1.43[a]
B 130	7.10±1.25[a]	6.90±1.11[a]	6.50±1.63[a]	6.95±1.27[a]	6.90±1.55[a]
C 320	7.10±1.41[a]	6.95±1.53[a]	6.65±1.38[a]	6.70±1.83[a]	6.80±1.47[a]
D 234	6.00±1.80[b]	6.55±1.95[a]	6.35±1.56[a]	6.30±1.65[a]	6.50±1.70[a]
E 182	7.15±1.46[a]	7.20±0.89[a]	6.15±1.42[a]	6.95±1.09[a]	6.90±1.11[a]
F 301	6.80±0.69[ab]	6.30±1.34[a]	6.50±1.10[a]	6.55±1.35[a]	6.55±1.57[a]
G 194	6.65±1.42[ab]	6.30±1.52[a]	6.20±1.85[a]	6.20±1.67[a]	6.05±1.46[a]
H 361	6.65±1.38[ab]	6.30±1.55[a]	6.05±1.63[a]	6.25±1.80[a]	6.50±1.50[a]

Values are means ±SD of triplicate determination.
Means in the same column with different superscript are significantly different at ($p<0.05$).

Key:
(210) = locally grated/fermented for 12 hrs
(130) = machine crushed/fermented for 12hrs
(820) = locally grated/fermented for 24 hrs
(234) = machine crushed/fermented for 24hrs
(182) = locally grated/fermented for 48hrs
(310) = machine crushed/fermented for 48hrs
(194) = locally grated/fermented for 72hrs
(361) = machine crushed/fermented for 72 hrs

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