

Research Article

Total Cyanogen Content of Garri Flour Produced in Delta State, Nigeria: Potential Health Risk

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Abstract: Metabolic disorder strongly associated with food toxicants and unhealthy diets are increasing contributing to pain, disability and death in Nigeria. This study aimed to evaluate the cyanogen content of garri produced in Delta State, Nigeria and its potential health risk. Freshly produced gari samples were randomly collected from the six zones designed for the study. Five samples were collected from each zone and bulked together to form representative samples. Samples were analyzed monthly in each zone, for 6 month duration, spread between the dry and rainy season. A total of 36 samples were tested. Results showed mean total cyanogen content in the range of 7.5 ± 1.63 and 49.3 ± 5.2 ppm, respectively. Maximum cyanogen content was detected in the dry season samples (49.3 ± 5.2) and minimum cyanogen content detected in the rainy season samples (7.5 ± 1.63 ppm). The dry and rainy season samples differed significantly ($p < 0.05$). The results also revealed that 69.4% of the garri flour produced in Delta State had mean total cyanogen above the 10 ppm recommended by WHO for cassava flour. Finding revealed high dietary cyanogen exposure from the consumption of insufficiently processed cassava roots and possible contribution of garri flour to endemic metabolic disorder.

Keywords: Cassava roots, cyanogen, diseases, garri, short-cut method

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a staple food crops in tropical Africa and an important source of calories to about 500 million to 1 billion people in tropical countries (Sornyotha *et al.*, 2010). Depending on factors such as custom, local preference and available technology, cassava roots are processed into diverse products such as *garri*, *kafun*, *fufu* which are consumed widely in Nigeria and other West Africa countries, *ugali* and *kowon* in Uganda and Tanzania, *nshima* in Mozambique, *nsima* in Malawai, *ubugali* in Rwanda and *funge* in Angola (Hahn and Keyser, 1985).

Despite cassava roots contributions to food security in tropical Africa; cassava roots contain cyanogenic glucosides, linamarin and minute quantity of lotaustralin (methyl-linamarin) which during processing are hydrolysed (Fig. 1) by linamerase into acetone cyanohydrin and glucose. Cyanohydrin decompose spontaneously at $pH > 5$ or at elevated temperature of above $35^\circ C$ or action of hydroxynitrile lyases into soluble and volatile cyanide ions which are liberated during dewatering, fermentation and roasting operation (Bradbury, 2004; Cliff *et al.*, 2011). Cyanides are mitochondrial oxidative phosphorylation blockers and interferes with enzymes and specific organs functions (Bergmann and Keller, 2003). Thus the resultant chronic toxicity and health disorders such as tropical ataxic neuropathy or spastic paralysis, konzo, goiter and cretinism are due to unhydrolysed cyanohydrins

associated with sustained intake of insufficiently processed cassava roots (Nhassico *et al.*, 2008; Dufour, 2011).

In Nigeria, cassava accounts for about 10% of the total per capita caloric value and second only to cereal grains which contributes about 40 and 50% (Onwuka, 2003). *Garri* is the most common form in which cassava roots is consumed in Nigeria (Ikediobi *et al.*, 1980). Its consumption cut across socio-economic classes and age groups, featuring regularly in most family daily diet (Adindu and Aprioku, 2006). The roots are processed traditionally into garri by peeling and grating. The grated pulp is dewatered and fermented for 72 h. The dewatered pulp is then sieved and roasted in an iron pan or earthen pot over a wood fire. This traditional method reduces toxic glucosides in cassava roots to a considerably safe level (Nambisian, 2011). However, rapid urbanization, increased mobility, unemployment and poverty have resulted in an unprecedented demand for garri. The aftermath is the use of short-cut method in which the established processing steps are reduced to less than 24 h; resulting in garri flour with unsafe cyanogen content far above the WHO safe level of 10 ppm recommended for cassava flour (FAO/WHO, 1991).

Previous studies on *garri* flours procured from markets and communities in Nigeria have revealed an alarming presence of cyanogen above the 10 ppm recommended for cassava flour (Omoike and Adediran, 1991; Odoemelan, 2005; Adindu and Aprioku, 2006;

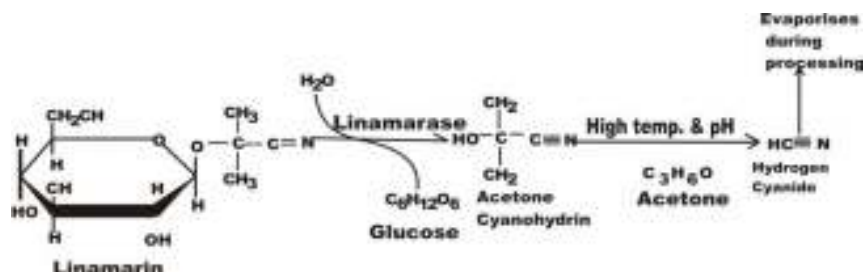


Fig. 1: Enzymatic degradation of toxic cyanogenic glycosides in cassava root

Komolafe and Arawande, 2011). In Delta state south-south Nigeria, *garri* is consumed as main meal (eba) or eaten as snacks or soaked in water, sweetened with sugar, milk and consumed with boiled beans, roasted groundnut, coconut and dried fish (UNICEF/IITA, 1989). Yellow *garri* flour produced by mixing grated pulp with palm oil before or after dewatering and fermentation is the most popular amongst the household. Observational survey of *garri* processing household in the state exposed an apparent lack of standardization and use of short-cut method of production in a bid to increase turnover and maximize profit. Furthermore, non-communicable diseases like blindness, strokes, deafness, unsteady walking, hypertension, chronic kidney diseases and diabetes are increasingly becoming an emerging health care burden and reason for hospitalization (Odenigbo and Ogujiofor, 2009). This underscore this study aimed at investigating cyanogen content of *garri* flour produced in Delta state and its potential health risk as the *garri* flours produced via short-cut method forms the bulk of the population ingested foods in terms of energy (kilocalories/kilojoules).

MATERIALS AND METHODS

Sampling: The state was divided into 6 zones to ensure adequately representative sampling namely: Agbor (Zone one), Kwale (Zone two), Ozoro (Zone three), Ughelli (Zone four), Sapele (Zone five) and Warri (Zone six). Initial survey was conducted to identify major *garri* producing communities in each zone. In each zone *garri* samples were randomly collected from five *garri* producing household and mixed together to obtain representative sample. Sample from each lot was analyzed in each month for six months, spread between the rainy season (May-July, 2011) and dry season (January-March, 2012). A total of 36 *garri* samples were analyzed. Each representative lot for each month and zone were packaged and labeled appropriately. Analysis was done within 96 h.

Evaluation of total cyanogen: A semi-quantitative method based on elution of the picrate paper and spectrophotometry (Ikediobi *et al.*, 1980; Edwards and

Williams, 1980) was used. Absorbance of the solution of HCN reacted picrated paper was measured against the blank at 510 nm using Bausch and Lomb 20 spectronic spectrophotometer. Cyanogen content in ppm was obtained by multiplying the absorbance (A) by 396.

Data analysis: Mean and standard deviation were used for data analysis. Duncan's Multiple Range Test (DNMRT) was used to separate the means. Significance was accepted at $p < 0.05$.

RESULTS AND DISCUSSION

The results of the mean total cyanogen (ppm HCN equivalent, mg/kg sample) of *garri* samples produced at the different zones designed for the study are shown in Table 1. The mean total cyanogen of the *garri* samples varied from 7.5 ± 3.63 to 49.3 ± 1.1 ppm, respectively. The *garri* produced in zone 3 (Ozoro) in the month of June, 2011 had the lowest mean total cyanogen of 7.5 ± 3.63 , while the highest mean total cyanogen of 49.3 ± 1.1 ppm was identified in *garri* samples produced in zone 1 (Agbor) in the month of March, 2012. The study outcome uncovered that only 30.6% (11/36) of *garri* samples produced at the zones designed for the study possessed mean total cyanogen within the WHO safe level of 10 ppm recommended for cassava flour, while 69.4% (28/36) of the samples had mean total cyanogen above the safe level. The results indicated that the mean total cyanogen content of *garri* samples produced in Delta state were generally higher than the 10ppm WHO recommended safe level of cyanogen in cassava flour (FAO/WHO, 1991; Odoemelan, 2005) in a previous study on residual cyanide content in *garri* flour revealed that cyanides values decreased significantly with length of the fermentation period. Accordingly, the high cyanogen content detected in this present study is symptomatic of the use of short-cuts in established method of cassava roots processing into *garri* flour; this reduces the fermentation (Komolafe and Arawande, 2011) and contact time needed for complete hydrolysis of cyanogenic glycoside by inherent (endogenous) and microbial linamarase (exogenous) into cyanide, acetone and glucose (Okafor and Ejiofor,

Table 1: Total cyanogen content of garri samples produced in Delta state, Nigeria

Zones	May, 2011	June, 2011	July, 2011	Jan., 2012	Feb., 2012	Mar., 2012
Agbor (1)	27.1±1.5c	20.9±3.7b	17.7±1.5b	31.7±0.5c	27.1±0.4c	49.3±1.1d
Kwale (2)	19.5±0.7b	9.80±2.2a	11.1±3.1a	22.1±1.1b	41.2±0.9d	29.7±0.11c
Ozoro (3)	11.7±1.9a	7.50±3.63a	10.3±0.9a	10.0±1.33a	9.30±2.2a	24.2±3.3c
Ughelli (4)	8.90±4.1a	17.2±1.3b	9.90±0.2a	17.7±3.1b	18.9±1.4b	17.6±0.6b
Sapele (5)	9.03±2.2a	8.10±4.1a	11.7±2.3a	13.1±1.2a	13.6±3.5a	14.1±0.7a
Warri (6)	9.11±1.3a	10.0±1.1a	13.3±0.7a	19.1±3.5b	17.3±1.2b	10.0±4.1a

*: Results are expressed as means of triplicate determination ±S.E. (data expressed in ppm equivalent of HCN (mg/kg sample)); Standard Error Mean (SEM) values with different superscripts letters are different at (p<0.05)

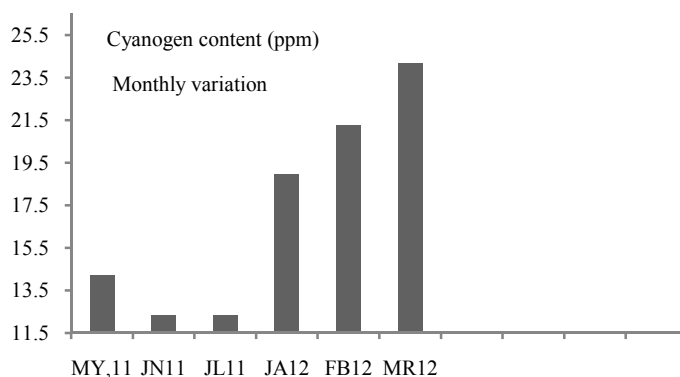


Fig. 2: Monthly grand total mean variations of total cyanogen in garri flours produced in Delta state, Nigeria

*: Expressed in ppm equivalent of HCN (mg/kg sample)

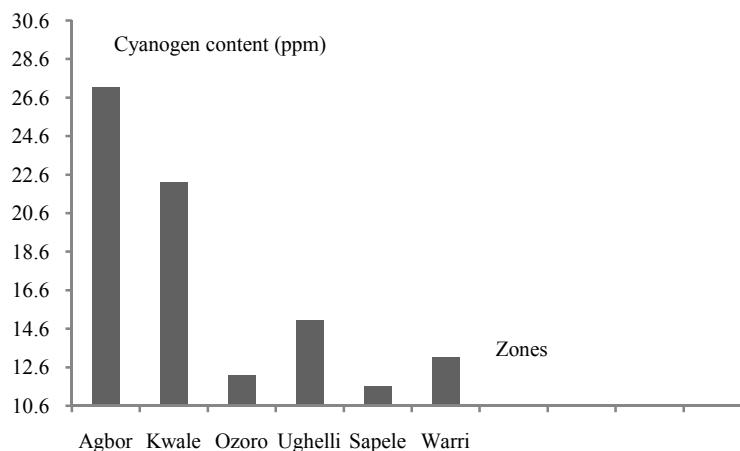


Fig. 3: Zones grand total mean cyanogen variations

1990). The cyanide which is volatile and soluble in water escapes during dewatering, fermentation and roasting operations.

The short-cut method of production results in incomplete hydrolysis of acetone cyanohydrins (Onwuka, 2003). Thus acetone cyanohydrins is the major cyanogen found in insufficiently detoxified garri flour (Bradbury and Denton, 2010) and are hydrolyzed rapidly to poisonous hydrogen cyanides on consumption, due to high pH of human gut into acetone and poisonous cyanides (Oluwale *et al.*, 2003). 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 (Akintonwa *et al.*, 1994; Madhusudanan *et al.*, 2008). The increasing incidences of cyanides related complications like dizziness; headache, blindness, deafness, abdominal pains, vomiting, diarrhea and unsteady walking in Delta State, especially among the poor rural elderly population is an upshot of high dietary exposure to un-hydrolyzed acetone cyanohydrins. These metabolic disorders are most often associated with interplay of supernatural forces or divine punishment or

sorcery in Africa (Tyllester, 1994). Its specific prevalence among the older and rural poor with monotonous diet of cassava diets, maybe explained by the fact that, rhodanese 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 (WHO, 2004; Cliff *et al.*, 2011). Moreover, as aging process progresses the liver ability to secrete rhodanese reduces, causing cyanides level in the blood to increase; this explains the preponderance of the resulting metabolic disorders amid the aging population.

The variations in the monthly and zones grand mean total cyanogen of garri flour produced in Delta State are shown in Fig. 2 and 3. The monthly grand mean total cyanogen ranged between 12.30 to 24.5 ppm, while the zones grand mean total cyanogen ranged between 11.61 to 28.93 ppm. Higher cyanogen content were detected in dry season samples in the range between 18.95 to 24.5 ppm (Table 2), while in the zones grand mean total cyanogen (Table 3), higher cyanogen levels (22.23 to 28.93 ppm) were detected in garri flours from Agbor (1) and Kwale (2) compared to other zones designed for the study namely: Ozoro (3), Ughelli (4), Sapele (5) and Warri (6). The two zones (Agbor and Kwale) are homes to major garri producing communities and muster markets in Delta State, Nigeria and also provided the bulk of garri flour consumed in Nigeria and other West African countries. The observed higher cyanogen level detected in Agbor (1) and Kwale (2) are perhaps explained by the expression of starch from cassava pulps in other zones namely: Ozoro (3), Ughelli (4), Sapele (5) and Warri (6) which aided the observed cyanogen level reduction in the zones and forms the basis for simple wetting method (Bradbury and Denton, 2010), unlike in Agbor (1) and Kwale (2) where starch is not commonly expressed from the pulp before fermentation. The inhabitants of these zones are predominantly from Urhobo, Isoko and Iteskiri ethnic nationalities of Delta State and starch meals is a common staples.

The mean total cyanogen in the 18 garri samples from the Month of May, 2011 to July, 2011 (rainy season) had 44.4% (8/18) of cyanogen below the WHO safe level, with a range of 7.5±3.63 to 27.1±1.5 ppm, while the mean total cyanogen in the 18 garri samples from the month of January, 2012 to March, 2012 (dry season) had 83.3% (15/18) unsafe cyanogen levels, with a range of 9.3±2.2 to 49.3±1.1 ppm. The variations which were statistically significant ($p < 0.05$) were due to lack of standardization in garri processing methods

Table 2: Monthly grand mean total cyanogen of garri flours produced in Delta state, Nigeria

May, 2011	June, 2011	July, 2011	Jan., 2012	Feb., 2012	Mar., 2012
14.22	12.30	12.33	18.95	21.23	24.15

*: Expressed in ppm equivalent of HCN (mg/kg sample)

Table 3: Grand total mean cyanogen for each zone in ppm equivalent of HCN (mg/kg sample)

Zones	Grand mean (ppm)
Agbor 1	28.93
Kwale 2	22.23
Ozoro 3	12.17
Ughelli 4	15.03
Sapele 5	11.61
Warri 6	13.14

(Odoemelan, 2005; Adindu and Aprioku, 2006). Furthermore the types of cultivars used and time of harvesting may have contributed also to the detected variations (Komolafe and Arawande, 2011). The variation in total mean cyanogen content in garri (S, 2011) and dry season (January-March, 2012) witnessed in this present study were due to lower dry matter content of cassava roots during rainy season compared to dry season (Hahn and Keyser, 1985). Additionally the partial seepage of soluble cyanogenic glucosides into the soil during rainy season may also have contributed to the variations, as rainy season cassava roots contains less toxic element, compared to dry season cassava roots (Tchacondo *et al.*, 2011). The unsafe cyanogen levels of cassava flour (garri) produced in the dry season with only 16.6% (3/18) safe cyanogen levels exposed an apparent risk of cyanides toxicity and urgent need for complete detoxification of the cassava roots.

CONCLUSION

The study unmasked the latent danger created by short cut method of garri processing and its precarious cyanogen content. Apparent lack of standardization, use of different cultivars and seasonal factors were observed to be responsible for the variations. Effective policy framework and Education of target population aimed at transmitting the appropriate processing and improved method of cassava roots processing is therefore recommended.

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