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The Hydrocyanic Acid (HCN) Content of *Garri* Flour Made from Cassava (*Manihot* spp.) and the Influence of Length of Fermentation and Location of Source

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ABSTRACT

White and yellow garri *flour—products derived from cassava (* Manihot *spp.) roots—collected from fifteen locations in Nigeria, were analysed for their HCN contents using the alkaline titration method of the Association of Official Analytical Chemists (AOAC) (1970) and the alkaline picrate method of Williams & Edwards (1980).* Garri *flour was also produced from mashed cassava roots which had been subjected to fermentation for time periods of between 0 and 72 h, and HCN levels monitored by the two indicated methods.*

HCN levels were influenced significantly by the source of the flour, the type of flour (whether white or yellow), the method of determination and the length of fermentation of the grated cassava mash.

It is suggested that these factors should be taken into consideration in the evaluation of the products for toxicity.

INTRODUCTION

Garri flour constitutes a major food resource for many people in Africa, Latin America and, probably, in the other developing countries of the world. In a world that is systematically undergoing cultural integration, *garri* flour may well become a more important food item even in the affluent developed world.

It is usually prepared from cassava (*Manihot* spp.) root essentially by mechanical mashing, fermentation in jute bags or other suitable materials

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for about three days, and subsequent light roasting in metallic vats placed on open fires. This is the traditional processing method and, by far, still the most popular. However, the process is undergoing increasing modernization with respect to the level of automation. To prepare yellow *garri* flour, it is customary to add some palm oil to the cassava mash at the stage of roasting; the cassava mash roasted without the addition of palm oil, or, for that matter, any other type of oil, constitutes the white *garri* flour.

All the known methods of *garri* flour production usually do not result in the complete detoxification of the flour with respect to cyanide content. The toxicity of HCN is well documented (Montgomery, 1969; Coursey, 1973; Maduagwu & Adewale, 1981; Oke, 1968 and many others).

Two of the methods used in the quantification of the cyanide contents of foods are the alkaline titrimetric method (AOAC, 1970) and the spectrophotometric alkaline picrate method (Williams & Edwards, 1980).

In the present studies, the HCN contents of white and yellow *garri* flours obtained from fifteen different locations have been determined by using the two methods indicated above. The influence of length of fermentation on the cyanide content of the final *garri* flour has also been examined. Given the toxicity of HCN, it is important to have a knowledge of factors which affect reported cyanide levels in *garri* flour. Only then can reliable data be available in formulating public health policies aimed at monitoring and minimising cyanide levels in *garri* and, in fact, in other foods containing toxic cyanogenic glycosides.

MATERIALS AND METHODS

Garri flour samples were obtained from markets in Bendel, Imo and Ogun States in Nigeria and random sampling was restricted to fifteen different locations.

Additionally, *garri* flour was produced by a traditional method essentially as described below. Mature cassava roots harvested from a farm at Emeabiam-Owerri in Imo State in Nigeria, were peeled manually with the aid of a knife to expose the pulp. The peeled cassava roots were then washed in clean water, drained and grated in a Lister Diesel Grating Machine (2·7 kW, 3·5 hp). The resulting pulp was packed in a jute bag and pressure applied by placing the bag between a set of two heavy sticks placed on top of the bag and another set of two placed underneath—both sets being tied fast with the aid of two strong fibrous ropes. This arrangement generated enough pressure to express much of the unwanted liquid from the grated cassava root pulp.

The retained pulp was left thus to ferment at ambient conditions

TABLE 1
The HCN Contents of *Garri* Samples[a] (μg/g dry matter) and the Effects of Length of Fermentation, Method of Determination and Type of *Garri*

Length of fermentation (*h*)	*Alkaline titration method*		*Alkaline picrate spectrophotometric method*	
	White garri	*Yellow* garri	*White* garri	*Yellow* garri
0 (Pre-fermentation)			303·47 ± 3·21	
6	59·1 ± 4·8	39·9 ± 3·7	37·9 ± 0·6	26·9 ± 0·7
12	28·2 ± 2·1	13·8 ± 1·6	23·9 ± 0·4	17·7 ± 0·3
24	9·59 ± 2·40	12·2 ± 2·6	16·5 ± 0·9	16·2 ± 0·2
48	6·18 ± 0·00	5·94 ± 1·05	10·6 ± 0·7	0·91 ± 0·06
72	3·09 ± 0·25	3·12 ± 0·50	3·52 ± 0·66	1·38 ± 0·12

[a] Results are expressed as ± SE of means of, at least, triplicate observations.

(21 ± 5°C) from 0 to 72 h. At intervals (as indicated in Table 1), fixed amounts of the fermenting cassava pulp were withdrawn for subsequent light roasting at 80°C in a metallic circular frying pan (diameter = 75 cm). Each sample withdrawn was divided into two equal portions: one for roasting with addition of palm oil (15 ml palm oil: 1 kg cassava mash) to yield the yellow *garri* flour and the other, roasted without the addition of any oil, which yielded the white flour.

Estimation of cyanide levels in the *garri* flour samples

The levels of cyanide in the white and yellow *garri* flour samples obtained from the fifteen different locations and of samples fermented for differing time periods (0, 6, 12, 24, 48 and 72 h) were estimated by two methods. These were the alkaline titration method (AOAC, 1970) and a spectrophotometric alkaline picrate method (Williams & Edwards, 1980).

Results were analysed statistically (standard error (SE), *t*-test and analysis of variance (ANOVA)) by use of the Statistical Package for the Social Sciences (SPSS), at the Computer Centre of the University of Benin, Benin City, Nigeria.

RESULTS AND DISCUSSION

The results presented in Tables 1 and 2 suggest that the reported cyanide levels in *garri* products could be influenced by the method of determination.

TABLE 2
The HCN Contents of *Garri* Samples[a] (μg/g Dry Matter) Determined by Two Methods and Obtained from Different Locations in Nigeria

Locations	*Alkaline titration method*		*Alkaline picrate spectrophotometric method*	
	White garri	*Yellow* garri	*White* garri	*Yellow* garri
1	18·2 ± 1·5	33·4 ± 0·5	16·9 ± 0·5	3·35 ± 0·18
2	24·3 ± 0·5	8·54 ± 1·05	10·2 ± 0·1	6·66 ± 0·30
3	18·3 ± 0·5	15·2 ± 1·5	23·9 ± 1·1	2·63 ± 0·90
4	15·3 ± 1·2	3·05 ± 0·42	8·81 ± 0·24	5·39 ± 0·06
5	2·92 ± 0·26	14·0 ± 0·5	9·50 ± 0·54	3·03 ± 0·42
6	23·9 ± 0·10	8·70 ± 0·05	16·6 ± 0·6	28·0 ± 1·2
7	27·6 ± 1·50	6·03 ± 0·06	20·5 ± 0·1	27·0 ± 0·5
8	9·79 ± 1·50	8·74 ± 0·63	4·09 ± 0·72	3·37 ± 0·06
9	2·92 ± 0·50	2·96 ± 1·05	2·33 ± 0·66	2·04 ± 0·54
10	5·82 ± 0·05	3·04 ± 0·32	4·32 ± 0·42	3·95 ± 0·30
11	27·3 ± 0·1	9·10 ± 1·10	11·4 ± 0·8	7·45 ± 0·60
12	15·3 ± 0·5	33·0 ± 0·3	13·5 ± 0·2	10·8 ± 1·2
13	36·6 ± 0·3	2·38 ± 0·05	10·9 ± 0·5	1·35 ± 0·48
14	15·4 ± 1·1	3·06 ± 0·05	8·13 ± 0·06	13·5 ± 1·0
15	21·4 ± 1·2	6·06 ± 1·05	3·33 ± 0·24	5·33 ± 0·90

[a] Results are expressed as ± SE of means of, at least, four readings.

The mean cyanide values obtained with both methods were statistically significantly different (T-test, $\alpha = 0{\cdot}01$, 10 df). Generally, the alkaline titrimetric methods gave higher HCN values than the alkaline picrate spectrophotometric method. Evidently, the level of interference from non-cyanide materials in the spectrophotometric method was, for the most part, lower than that in the titrimetric method. However, it is possible to have incomplete uptake, by the alkaline picrate, of the emitted HCN, or to have incomplete elution of reaction product (absorbance at 510 nm is measured) in the alkaline picrate spectrophotometric method. Both factors could lower the values obtained with the spectrophotometric method.

The HCN contents of the white and yellow *garri* flour obtained from cassava root mash which was allowed to ferment for time periods ranging from 0–72 h are given in Table 1. Decreases in the HCN levels with increasing length of the fermentation periods are observed. The decreases were statistically significant ($P < 0{\cdot}05$) and are attributable to the breakdown of the cyanogenic glycoside—the form in which cyanide usually occurs in *Manihot* roots. The breakdown, which could be microbiological and is catalysed by linamarase, releases the glycone (sugar moiety) and the aglycone (non-sugar moiety) of the glycosides. The mechanisms has been discussed by many workers (Conn, 1973). The point to be emphasised here

is that the growing practice by many processors to reduce the fermentation period of cassava mash in an attempt to increase turnover rate should be discouraged on toxicological grounds. Clearly, the suggestion is that the longer the fermentation period, the less the residual cyanide content of the final product.

The results in Tables 1 and 2 indicate that the white *garri* flour, for the most part, had higher HCN contents than the yellow flour. The differences which were statistically significant (T-test, $\alpha = 0{\cdot}01$, df 10 and 28, respectively) are probably attributable to the added palm oil which formed an oily layer around each *garri* flour particle, acting as a heat-exchange medium and enhancing a thermocatalytic breakdown of the cyanogenic glycoside during the roasting of the yellow *garri*. Again, since glycosides are usually surface active, a surface alignment could occur between the cyanogenic glycoside and the oil of the *garri* flour particles in such a way that the glycoside becomes more susceptible to thermocatalysed breakdown at 80°C. Finally, because of the hydrophobic surface created on each yellow *garri* flour particle by the addition of palm oil, a higher residual internal moisture can be predicted for the yellow *garri* flour. This would translate to a higher hydrolytic breakdown of the glycoside in the yellow flour and, consequently, to a lower HCN content derivable from the reduced level of residual glycoside. A higher residual internal moisture in the yellow *garri* could also, in fact, stimulate the decomposing action of linamarase, assuming that the enzyme is still active, even if minimally, at the light roasting temperature of 80°C.

In Table 2, the cyanide levels in the market-purchased *garri*, which will have had 3 days' fermentation as indicated earlier, generally exceeded the cyanide levels in the 3-day laboratory fermented samples (Table 1). This could be attributed to reduced levels of detoxification in the market-purchased *garri*; it has been indicated earlier that, in order to increase turnover rate and, therefore, profits, some processors are now reducing fermentation periods.

Locational variations in the HCN contents of the *garri* flour samples are discernible in Table 2; the variations were significant ($P < 0{\cdot}01$) as determined by ANOVA. This is a reflection of lack of standardisation in the processing methods of *garri* production. Especially in the traditional methods of production, the extent of pulping, length of fermentation, frying temperature and other parameters vary from one processor to the other. This state of affairs is probably true of the other less developed countries where *garri* is an important food item. Maner & Gomez (1973) have indicated that long term consumption of cassava products containing low levels of HCN produces goitre and neuropathy. For such a toxic substance-containing but popular food, it is imperative to have a standardised method of production and raw material type, to ensure very minimal, if not zero,

levels of HCN in the final product. In Table 2, the HCN levels range from about 1·4 to about 33·4 μg/g dry weight of flour. Nartey (1973) has suggested that 50 mg/kg body weight could be lethal to man, implying that a 50 kg individual will have to consume between about 75–1786 kg dry flour to possibly experience the lethal effects of HCN poisoning.

CONCLUSION

It is concluded therefore that the length of fermentation of cassava root mash or pulp, the type of *garri* flour (whether white or yellow), the source of the flour and the method of determination could affect the levels of HCN detected in *garri* flour. These factors should be reckoned with in any meaningful toxicological assessment of the products.

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