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# Effect of different processing methods on cyanide content of garri from four cultivars of cassava

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## Abstract

Effect of different processing methods on cyanide content of garri was studied in three improved cassava cultivars (NR 8082, TME 419 and TMS 4(2) 1425) as well as a local unimproved cultivar (Obubit Okpo). Stem cuttings from these cultivars were planted in a randomized complete block design with 4 replications. The experiment was factorial involving three factors, namely cultivars, fertilizer and fermentation days. NPK fertilizer (15:15:15) was applied twice at a rate of 650 kg per hectare. Tubers were harvested at the age of 7 months and their weights taken per stand. The tubers were peeled, grated, fermented (for 1, 2 and 3 days), sieved and fried. Sampling for HCN was done at three stages: immediately after grating the tubers, after fermentation and after frying. Estimation of HCN was done using the silver nitrate volumetric analysis. Our results showed that there was no significant correlation ($p>0.05$) between cyanogenic glucoside level and crop yield. Fertilizer application significantly ($p<0.05$) increased the cyanide content of the fried product in all the 4 cultivars. The bulk of cyanide reduction was achieved during fermentation, which was further enhanced by frying. The optimum fermentation days varied with the cultivars; for NR 8082 and the local cultivar it was 3 days while for TMS 4(2) 1425 and TME 419 it was 2 days. It is therefore pertinent to advise that farmers should exercise some restraint in their choice of planting material as well as the processing methods, as the later clearly depends on the former.

***Key words:*** Cassava cultivars, NPK fertilizer, fermentation, garri, hydrocyanic acid.

## Introduction

Cassava (*Manihot esculenta* Crantz) is an important root crop in Africa, Asia, South America and India, providing energy for about 500 million people [1]. The tuber consists of 20-35% starch with very limited quantities of protein, fats, vitamins and minerals [2]. In addition, the roots contain considerable quantities of the antinutrient factor, cyanide, which occurs in the form of two cyanogenic glucosides, linamarin and lotaustralin. Interestingly, enzymes present in plant are hydrolytic enzymes, which are capable of breaking down these glucosides to free cyanide. This, however, can only be made possible when there is a rupture of the cell walls for example by grating, crushing, microbial fermentation, enzymatic action or a combination of these, which brings the enzymes into direct contact with the glucosides [3].

When cassava products are used as a primary staple food, careful processing to remove or reduce toxic constituents is therefore required to avoid chronic cyanide intoxication. Incomplete processing may result in high cyanide exposure giving rise to severe diseases like tropical ataxic neuropathy and konzo, when consumed for prolonged period especially in populations with poor nutritional status [4, 5]. Mayambu [6] thus summarized the four factors that combine to determine the risk of cyanide poisoning as the level of cyanogenic glucoside in fresh roots, insufficient processing, presence of other nutritional deficiencies and the dose and length of exposure.

Efficient cassava processing can reduce the cyanogenic glucoside content of roots of even the most potentially toxic varieties to safe levels [3]. Fermentation of cassava pulp helps to detoxify hydroxylamine acid as well as impart flavour [7]. Mahungu *et al.* [8] reported that garri obtained through the proper processing procedures involving grating fermentation and frying could give as much as 80-90% cyanide reduction relative to freshly peeled roots. Oke [9] reported an HCN content of 1.9 mg/100 g for garri while Akinrele *et al.* [10] obtained 0.3 mg/100 g. Nigeria Food and Drug Administration and Control stipulate safe level of cyanide in garri to be 19 ppm, which means 1 mg HCN per 100 g of garri.

The effect of NPK fertilizer on cyanide content has been quite controversial in cassava. Okigbo [11] suggested that glucoside level in cassava was increased by the deficiencies of potassium, phosphorus and nitrogen while Jorgensen *et al.* [12] reported an increase in cyanogenic glucoside with the supply of potassium, phosphorus and nitrogen through application of NPK (15:15:15).

The present paper is aimed at determining the effect of different fermentation days (as currently used in this locality) on the cyanide level in four cassava cultivars. Such detailed reports are presently lacking on these cultivars. It will also throw more light on the effect of NPK fertilizer on the cyanide content of these plants, which appears to be controversial for now.

## Materials and Methods

***Planting and cultural practices:*** A plot of land measuring 35 m x 7 m (0.00245 ha) was cleared manually, tilled and 4 ridges measuring 33 m x 0.85 m made. The spacing between the ridges was 0.6 m. Stems of three cultivars of cassava (NR 8082, TME149, TMS 4(2) 1425) were obtained from Akwa Ibom Agricultural Development Programme (AKADEP), Nigeria, while the fourth (local cultivar Obubit Okpo) was collected from a local farmer in Calabar, Nigeria.

The cuttings from each cultivar, measuring 27 cm in length, were planted at about 45° on the crest of the ridges [11]. Care was taken to ensure that the buds were not inverted during planting, as would have led to delayed sprouting [11]. Planting distance was 1 m x 1 m. The experimental design was randomized complete block design (RCBD) in a factorial (4 x 4 x 2) format with 4 replications, thus giving 128 planting stands in the plot. The factors were cassava cultivars, fermentation levels and fertilizer application. Weeding was done at 4, 8 and 12 weeks, respectively, after planting, since the crop was planted as a sole crop [13].

NPK (15:15:15) fertilizer obtained from Cross River Agricultural Development Programme, Cross River, Nigeria, was applied to the crops twice at a rate of 650 kg per hectare each time. The first application was after one month of planting, top dressing was done 4 weeks after the first application [14]. Tubers were harvested at the age of 7 months and their weights taken per stand.

***Processing of tubers:*** The harvested tubers were sorted by visual assessment and the good ones separated from the spoilt ones. The good ones were peeled manually with a knife (six hours after harvesting) [7, 14] and washed. Tubers were grated manually after which samples were collected immediately for the first HCN content analysis.

The grated mash was then fermented for 1, 2 and 3 days (according to the experimental design) in labeled jute bags during which water was squeezed out with the help of ropes and wood. The contents of each bag were sieved at the end of the fermentation period allotted to each one. Samples were thereafter collected for the second analysis for HCN content and the remaining were fried till the particles were crisp and dry.

Frying was done using an iron pan, stirring was facilitated using a concave piece of local calabash. After frying the garri was spread on labeled jute bags on the floor to cool. After 6 hours, it was sieved and samples were collected for the final HCN analysis. Sampling for HCN was thus done at three stages: immediately after grating the tubers, after fermentation and after frying.

***Estimation of hydrocyanic acid (HCN) content:*** Estimation of hydrocyanic acid was done using the silver nitrate volumetric analysis [15]. Ten grams of the sample was weighed into a round-bottomed flask and left to soak for 4 hours in 200 ml of water. It was then steam-distilled until 150 ml of the distillate was collected and 8.0 ml of 6 N $NH_4OH$ and 2 ml of 5% (w/v) were added to the distillate. It was then titrated with 0.02 N $AgNO_3$ until there was a faint but permanent turbidity. The determination was carried out in triplicates. Calculation of the cyanide was done using the conversion formula; 1ml of 0.02 N $AgNO_3$ = 1.08 mg HCN [15].

***Statistical analysis:*** Data collected were subjected to analysis of variance (ANOVA) test and the means were separated using least significant difference test (LSD). A linear correlation analysis was also done to establish the relationship between cyanide content and mean tuber yield per plant in different cassava cultivars [16].

## Results

Table 1 shows the effect of fermentation and fertilizer application on the mean hydrogen cyanide content (mg) of raw cassava mash in the four cultivars studied. Table 2 presents the effect of fermentation and fertilizer application on the mean HCN content (mg) after processing into garri. Table 3 gives the relationship between tuber yield (kg) and glucoside content in the 4 cassava cultivars.

It can be seen from Table 1 that the HCN content of the unfermented (freshly grated) cassava mash was not significantly affected by NPK fertilizer treatment ($p>0.05$) except in cultivar TME 419, even though the values were generally lower after fertilizer treatment. However, the various levels of fermentation (1, 2 and 3 days) used in this study significantly reduced the HCN content to different levels in the 4 cultivars (Table 1). The reduction was highest in cultivars NR 8082 and Obubit Okpo after three days of fermentation with values of 38.67 and 60.27% respectively. Cultivars TME 419 and TMS 4(2) 1425 showed their highest reduction values of 51.74 and 49.0% respectively after only two days of fermentation.

It was clear (Tables 1 and 2) that the local cultivar (Obubit Okpo) had the highest HCN content in the unfermented mash. Its HCN content was also the most drastically reduced (60.27 and 67.04% for the fermented mash and fried products respectively).

It was again interesting to note (Table 2) that after frying, those samples without fertilizer application showed greater percentage reduction ($p<0.05$) in cyanide content than those treated with fertilizer. This was quite consistent in all the cultivars studied. TMS 4(2) 1425 and TME 419 had the highest cyanide reduction percentage of 66.10 and 52.66% respectively from those fermented for 3 days while NR 8082 had its highest reduction level of 56.08% from just 1 day of fermentation.

## Discussion

The highest percentages of cyanide reduction achieved in the present study were 66.1% for TMS 4(2) 1425, 52.60% for TME 419, 56.08% for NR 8082 and 67.04% for the local 'Obubit Okpo'. These values are higher than the 50% reduction level reported [7] after 96 hours of fermentation. Our values, however, are lower than the 80-90% reduction level [8]. These differences may be attributed to the cassava processing methods as well as the HCN estimation methods used in the different cases. The bulk of cyanide reduction in the present study was achieved during fermentation. This confirms the report by Bokanga *et al.* [3].

The present study revealed that the optimum fermentation days depended on the local cultivar. Cultivar NR 8082 and the local cultivar had their highest reduction level after 3 days of fermentation, the other 2 cultivars (TMS 4(2) 1425 and TME 419) after 2 days of fermentation. It is in fact possible that increasing the fermentation days beyond what was used in this experiment may further reduce the cyanide content in those two cultivars that peaked at 3 days of fermentation.

Earlier reports [11, 12] were controversial on the effect of fertilizer on cyanide content in cassava. Our results indicate that fertilizer application significantly increased ($p<0.05$) the cyanide content of the final product in all the 4 cultivars (Table 2). This is, therefore, in agreement with the report of Jorgensen *et al.* [12] and at the same time in disagreement with Okigbo [11].

It was quite obvious that the three improved cultivars had several

**Table 1.** The effect of fermentation and fertilizer application on the mean HCN content (mg) of raw cassava mash in four cassava cultivars.

| Fermentation level | Fertilizer application | Cultivar | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | TMS 4(2) 1425 | | TME 419 | | NR 8082 | | Obubit Okpo | |
| | | Mean | % Reduction | Mean | % Reduction | Mean | % Reduction | Mean | % Reduction |
| Unfermented | No fertilizer | 3.51bc | | 3.38b | | 3.62ab | | 4.43a | |
| | 65 g/plant | 3.16cd | | 2.30d | | 3.19bc | | 4.10a | |
| 1 day | No fertilizer | 2.76de | 21.37 | 3.28bc | 2.96 | 2.97c | 17.96 | 2.38cd | 46.28 |
| | 65 g/plant | 2.49ef | 21.20 | 2.84c | 23.48 | 3.94a | 23.51 | 3.06b | 25.37 |
| 2 days | No fertilizer | 1.79g | 49.00 | 4.14a | 22.49 | 3.62ab | 0 | 2.05de | 53.72 |
| | 65 g/plant | 2.05fg | 35.13 | 3.49b | 51.74 | 2.92c | 8.46 | 4.03a | 1.71 |
| 3 days | No fertilizer | 4.99a | 42.17 | 2.20d | 34.91 | 2.22d | 38.67 | 1.76e | 60.27 |
| | 65 g/plant | 3.94b | 24.68 | 3.49b | 51.74 | 3.35bc | 5.02 | 2.74bc | 33.17 |

Means followed with the same case letter in each column indicate no significance ($p>0.05$).

**Table 2.** The effect of fermentation and fertilizer application on the mean HCN content (mg) of fried garri from 4 cassava cultivars

| Fermentation level | Fertilizer application | Cultivar | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | TMS 4(2) 1425 | | TME 419 | | NR 8082 | | Obubit Okpo | |
| | | Mean | % Reduction | Mean | % Reduction | Mean | % Reduction | Mean | % Reduction |
| 1 day | No fertilizer | 1.84c | 47.58 | 1.84c | 45.56 | 1.59e | 56.08 | 1.50d | 66.14 |
| | 65 g/plant | 2.65a | 16.14 | 1.80c | 21.74 | 2.46a | 22.88 | 2.02c | 50.73 |
| 2 days | No fertilizer | 1.60d | 54.42 | 2.0b | 40.83 | 1.89c | 48.34 | 1.46d | 67.04 |
| | 65 g/plant | 2.24b | 29.11 | 1.46e | 36.52 | 1.79d | 43.89 | 2.41b | 41.22 |
| 3 days | No fertilizer | 1.19f | 66.10 | 1.60d | 52.66 | 2.05b | 43.37 | 2.08c | 53.05 |
| | 65 g/plant | 1.48e | 53.16 | 2.84a | 23.48 | 1.96c | 38.56 | 2.52a | 38.54 |
| | LSD (0.05) | 0.08 | | 0.08 | | 0.08 | | 0.08 | |

Means followed with the same case letter in each column indicate no significance ($p > 0.05$).

clear advantages over the unimproved cultivar as evidenced in their lower cyanide contents and higher tuber yield per plant than the local cultivar. Farmers are, therefore, encouraged, to go for improved varieties wherever possible.

Finally, since intensive processing of cassava generally results in loss of protein, vitamins and minerals, it is suggested that a more intensive search for ways of handling the HCN reduction at the molecular level be made. Previous studies have not revealed any significant correlation between the content of cyanogenic glucosides and crop yield [8]. Our present report confirmed this as it showed no significant relationship ($p>0.05$) between yield and cyanide contents in the cassava roots.

**Table 3**. Linear correlation coefficient between tuber yield and glucoside content in cassava.

| Treatment combination | x (yield in kg) | y (glucoside) | Cal r | Tab r (5%) |
|---|---|---|---|---|
| $AaCf_0$ | 5.0 | 7.02 | | |
| $AaCf_1$ | 16.38 | 12.64 | | |
| $AbCf_0$ | 6.5 | 10.15 | | |
| $AbCf_1$ | 10.0 | 6.91 | $0.415^{ns}$ | 0.707 |
| $AcCf_0$ | 14.0 | 7.23 | | |
| $AcCf_1$ | 18.88 | 12.75 | | |
| $AdCf_0$ | 2.25 | 8.86 | | |
| $AdCf_1$ | 6.25 | 12.31 | | |

x mean yield of tuber, y mean glucoside content, $Cf_0$ product without fertilizer, $Cf_1$ product with fertilizer, Aa TMS 4(2)1425, Ab TME 419, Ac NR 8082, Ad Obubit Okpo

## References


[1]Padmaja, G. 1995. Cyanide detoxification in cassava for food and feed uses. Critical Reviews in Food Science and Nutrition **35**(4):299-339.

[2]Rawal, H. M. and Kroll, J. 2003. Die Bedeutung von cassava (*Manihot esculenta* Crantz) als Hauptnahrungsmittel in tropischen Ländern. Deutsche Lebensmittel-Rundschau **99**(3):102–105.

[3]Bokanga, M., Essers, S., Poulter, N., Rosling, H. and Tewe, O. (eds) 1994. International Workshop on Cassava safety (WOCAS). Acta Horticulturae **375**.

[4]Hahn, S. K. and Keyser, J. 1985. Cassava - a basic food of Africa. Outlook on Agriculture **14**(2):95–99.

[5]Hahn, S. K. 1989. An overview of African traditional cassava processing and utilization. Outlook on Agriculture **18(**3):110-118.

[6]Mayambu, B. 1993. Cassava Processing: Dietary cyanide exposure and Konzo in Zaire. International Child Health Unit, Uppsala University, Children Hospital.

[7]Yussuf, I. G. and Oyeku, O. M. 2004. Processing of cassava into products: Technology requirement and economics. A paper presented during the Workshop on Akwa Ibom Cassava Competitive Project, 28th September 2004, Uyo, Nigeria.

[8]Mahungu, N. M., Yamaguchi, Y., Almazan, A. M. and Hahn, S. K. 1987. Reduction of cyanide during processing of cassava to some traditional African foods. Journal of Food and Agriculture **1**:11–15.

[9]Oke, O. L. 1968. Cassava as food in Nigeria. World Review of Nutrition and Dietetics **9**:227–230.

[10]Akinrele, I. A., Cook, A. S. and Holgate, R. A. 1962. The manufacture of garri from cassava in Nigeria. Proceedings First International Congress on Food Technology, London.

[11]Okigbo, B. N. 2001. Nutritional Implication of Giving High Priority to the Production of Staples of Low Nutritive Quality: The Case for Cassava (*Manihot esulenta* Crantz) in the Humid Tropics of West Africa. IITA, Ibadan, Nigeria.

[12]Jorgensen, K., Bak, S., Busk, P. K., Sorensen, C., Olsen, C. E., Puonti-Kaerlas, J. and Moller, B. L. 2005. Cassava plants with a depleted cyanogenic glucoside contents in leaves and tubers. Plant Physiol. **139**(1):363-370.

[13]Melinfonwu, A., James, B., Achou, K., Weise, S., Awah, E. and Gbaguidi, B. 2002. Weed Control in Cassava Farms. IPM Field Guide for Extension Agent.

[14]IITA 1991. Cassava in Tropical Africa. A Reference Manual. International Institute of Tropical Agriculture, Ibadan, Nigeria.

[15]AOAC 1990.Official Methods of Analyses. 13th edn, Association of Official and Analytical Chemists, Washington, DC, USA.

[16]Obi, I. U. 2002. Statistical Methods of Detecting Differences between Treatment Means and Research Metrology Issues in Laboratory and Field Experiments. AP Express Publishing Company Limited, Enugu.