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Physio-Chemical Properties and Cyanide Content of Garri Produced from Biofortified Cassava Cultivars Using Different Fermentation Methods

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ABSTRACT

Cassava is a staple food for over half a billion people in the developing world. Biofortified *garri* is described as yellow granular flour with a sour taste made from fermented, gelatinised fresh biofortified cassava roots. It can be consumed as snacks, a light meal when soaked in cold water and eaten with peanut, smoked fish, coconut or banana. *Garri* can also be consumed as a meal (when made into stiff dough-popularly referred to as *eba* and eaten with choice African soups). These make it the most popular diet amongst the rich and the poor, with acceptability cutting across the various socio-economic and multi-ethnic groups in Africa. It is produced by grating fresh roots into a mash, fermenting, de-watering, granulating, sifting, and roasting into gelatinised particles In this study, physio-chemical properties and the cyanide content of *garri* produced from biofortified cassava root cultivars were determined. The cultivars used were UMUCASS 45, UMUCASS 53 and UMUCASS 54. Fresh roots of these cultivars were harvested and processed into *garri* using three fermentation methods (Traditional, Backslopped, and Starter Culture). The ranges of pH of the *garri* samples were 4.01 to 4.28, 4.11 to 4.48, 3.92 to 4.16 and 4.03 to 4.50, while ranges of titratable acidity of the *garri* samples were 0.66 to 1.43, 0.66 to 1.37,0.63 to 1.85 and 0.88 to 0.99 for cultivars UMUCASS 45, UMUCASS 53, UMUCASS 54 and the control sample, respectively. The cyanide contents of the *garri* samples were in the ranges of 0.12 to 0.13, 0.10 to 0.14, 0.10 to 0.15 and 0.14 to 0.18 mg/100 g for cultivars UMUCASS 45, UMUCASS 53, UMUCASS 54 and the control sample, respectively. All the values obtained fell within the acceptable limits; this made the yellow *garri* of high-quality attributes.

Keywords: Biofortified cassava, *garri*, physio-chemical, hydrogen cyanide, and fermentation

INTRODUCTION

Biofortification has been proposed as a sustainable strategy to combat Vitamin A and other nutritional deficiencies (VijayaKumar *et al.,* 2025). In Nigeria, where strong breeding efforts exist, high-provitamin A cassava cultivars have been released since 2011 (IITA, 2017). These biofortified cassava varieties are known as "yellow cassava" being promoted in various communities, and are gaining momentum across the country (Harvest Plus, 2017; Oteh *et al*., 2023). These successes have spread to neighbouring nations in Sub-Saharan Africa, with the release of similar cultivars to combat Vitamin A Deficiency (VAD) in burdened populations (Eyinla *et al.,* 2019). Biofortification goes beyond ordinary fortification because it involves making plant foods more nutritious as they grow rather than adding nutrients to foods during processing (Malik and Maqbool, 2020). Biofortification records an improvement over ordinary fortification for making nutrients available to the poor people living in rural areas, who rarely have access to commercially fortified foods (Abbo, 2021). Thus, making cassava an ideal candidate for biofortification. Cassava clones with high levels of provitamin A carotenoids, zinc and iron have been developed by the International Centre for Tropical Agriculture and IITA (Njenga *et al.,* 2010).

Unlike white cassava, there is a delay in the onset of postharvest deterioration in biofortified cassava, which can be an advantage in its acceptability by farmers and consumers (Otun *et al*., 2023). Pro-Vitamin A cassava consumption can improve the nutrition of children and women, considered to be the most vulnerable to Vitamin A deficiency (Kolapo *et al*., 2020). Yellow cassava contains β-carotene, which is a precursor of Vitamin A in high levels (Olodude,2026). The ability to control processing conditions will retain and increase Vitamin A intake among the population and reduce problems associated with Vitamin A deficiency.

In Africa, cassava is one of the most important and abundant food crops from which varieties of fermented products are produced (Haakuria,2005). It is a substrate for many fermented foods at the subsistence level. Despite the importance of cassava and its food products, such as *garri*, a staple food in Africa, traditional production methods are time-consuming and labour-intensive. Obtaining good-quality *garri* from cassava takes about 96 hours, and fermentation is the primary step that accounts for most of the processing time.

Fermentation is reckoned as one of the oldest and most important biotechnological processes used in beverage and food production (Sokra and Meta, 2025). It is domestically and industrially used to enhance food quality and reduce toxic and antinutrient substances, like polyphenols and oxalic acids. phytic acid, hydrogen cyanide, stachyose and raffinose, among others, in order to increase the use of the food (Gibson, 2007). This research, therefore, studies the effects of fermentation method on physio-chemical properties and cyanide content of *garri* produced from three biofortified cassava cultivars.

METHODOLOGY

Three cultivars of biofortified cassava roots, UMUCASS 45, UMUCASS 53 and UMUCASS 54 used for this research were sourced from the Cassava Breeding Unit of the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. Starter culture was developed in the Microbiology Laboratory, Nigeria Institute of Science Laboratory Technology, Samonda, Ibadan, Oyo State, Nigeria.

Garri Production Using Traditional Fermentation Method

Garri was prepared using the traditional fermentation method, with slight modification, as described by Oyeyinka *et al*. (2019). 100 kg of freshly harvested biofortified cassava roots were weighed, peeled, washed and grated into mash using a motorised cassava grater. The roots were grated and packed into a sack, fermented for 96 h in a black plastic container that was covered, dewatered, and the cake was collected, pulverised, and garrified (75 °C; 16 mins) to produce *garri*.

Garri Production Using Backslopped Fermentation Method

Garri was also prepared using the backslopped method of fermentation as described by Awoyale *et al*. (2021), slightly modified. 200 kg of freshly harvested yellow cassava roots were weighed, peeled, washed and grated into mash using a motorised cassava grater. The grated mash was packed into a sack and spontaneously fermented (96 h) in a black coloured covered plastic container. The fermented mash containing the specific Lactic Acid Bacteria was used to produce backslopped cassava mash. Fresh 75 kg of the same cassava cultivar mash was weighed and mixed with traditionally fermented cassava mash containing the *Lactobacillus species* using a laboratory mixer, resulting in a homogeneous sample in the ratio 3:1. After this, the sample was bagged and fermented (48 h) in a black coloured plastic container. It was dewatered, pulverised and garrified (75 °C, 16 mins) using a stainless-steel roasting pan.

Garri Production Using Starter Culture Fermentation Method

Garri was prepared using the starter culture by Edward *et al*. (2012) modified method. 100 kg of freshly harvested biofortified cassava roots were weighed, peeled, washed and grated into mash using a motorised cassava grater. The grated mash was packed into a sack placed inside a black plastic container and blanched. Twenty (20) ml of the inoculum was introduced into the blanched cassava mash and allowed to ferment for 48 h. The fermented mash was dewatered, pulverised, and garrified (75°C, 16 mins) using a stainless-steel roasting pan.

Analyses

A waterproof pH meter was used to measure the pH values of the *garri* samples. Titratable acidity of the samples was determined by titration. Cyanide content was determined by the alkaline picrate calorimetric method of Bradbury *et al.* (1999).

Statistical Analysis

Data obtained were subjected to Analysis of Variance (ANOVA) using the Statistical Package for Social Scientists (SPSS version 21). Duncan's Multiple Range Test (DMRT) at 5% level of significance was used to separate the means.

RESULTS AND DISCUSSIONS

Physio-chemical properties of the *Garri* Samples

The results of the selected physio-chemical properties are as shown in Table 1. All the *garri* samples were slightly acidic for all the fermentation methods, and the range of values obtained was from 3.92 to 4.50. The pH values were found to be within the recommended range of 3.5 to 4.5 for fermented products (Sanni *et al.,* 2005; Farinde *et al*., 2023).

Table 1: Physio-Chemical composition of the *garri* samples obtained from three cultivars

Cultivar	Fermentation methods	PH	Total Titrable Acidity (TTA) %
UMUCASS 45	Traditional	4.01 ± 0.03^{g}	1.43 ± 0.00^{b}
	Backslopping	4.17 ± 0.01^{de}	0.83 ± 0.00^{g}
	Starter Culture	4.28 ± 0.03^{c}	0.66 ± 0.00^{h}
UMUCASS 53	Traditional	4.11 ± 0.01^{ef}	1.37 ± 0.00^{c}
	Backslopping	4.22 ± 0.02^{cd}	1.21 ± 0.00^{d}
	Starter Culture	4.38 ± 0.03^{b}	0.66 ± 0.00^{h}
UMUCASS 54	Traditional	3.92 ± 0.03^{h}	1.85 ± 0.01^{a}
	Backslopping	4.07 ± 0.03^{fg}	0.92 ± 0.02^{e}
	Starter Culture	4.16 ± 0.02^{de}	0.63 ± 0.01^{i}
UMUCASS 45 Control	Traditional	4.03 ± 0.03^{g}	0.88 ± 0.00^{g}
	Backslopping	4.20 ± 0.02^{d}	0.89 ± 0.01^{g}
	Starter Culture	4.50 ± 0.07^{a}	0.99 ± 0.00^{f}

Mean values with different superscripts along the same column are significantly different from each other ($p<0.05$)

This is an indication of good keeping quality. The lower the pH of a food, the more acidic it is. The resulting *garri* samples in this study had a pH that was significantly different ($p>0.05$). The pH indicates the acid content of food. It is a measure of hydrogen ion concentration in food samples.

Titratable acidity of the *garri* samples ranged from 0.63 to 1.85% and differed significantly (p>0.05). *Garri* sample produced from the cultivar UMUCASS 54, using starter culture, had the least (0.63) titratable acidity compared to the titratable acidity (1.85) obtained from *garri* sample produced from spontaneous fermentation method using variety UMUCASS 54. The higher the titratable acidity, the sourer the *garri* and the more acceptable it will be. Thus, *garri* samples produced from all the fermentation methods are likely to be acceptable to consumers in terms of sourness. Some of the *garri* samples had values of titratable acidity above 1.0%, which is the recommended upper limit for *garri* samples, while some were in agreement with Nigerian Industrial Standard NIS 181:2004 for *garri* (Farinde *et al*., 2023). The Codex standard TTA for *garri* is 0.6 and 1.0%, which is measured as lactic acid. (FAO, 2019). This indicates that the *garri* samples had sourness within the recommended values.

Cyanide content of the *garri* samples

The cyanide content of the *garri* samples is as shown in Table 2. The values ranged from 0.10 to 0.18 mg/100 g. The *garri* sample produced by the traditional method with UMUCASS 54 cultivar had the least cyanide content (0.10 mg/100 g). The variations in the cyanide content of the *garri* samples might be a result of the differences in the fermentation method and the cultivar used. Generally, biofortified cassava cultivars are classified as sweet because the hydrogen cyanide in their roots is lower compared with that of white cultivars. Previous studies have reported that fermentation could reduce the cyanide content of cassava products significantly (Obi *et al*., 2019). The cyanide content reported in this study is lower than the cyanide content (2.51 to 3.72 mg/kg) of *garri* samples marketed in Sango in Ibadan (Ojo and Afolayan, 2023). The cyanide content (0.10-0.18mg/100 g) of *garri* samples produced in this study is lower than the recommended safe level (10 mg/kg) of cyanide in cassava products (Enivwenae and Ughumiakpor, 2025).

Table 2: Cyanide content of the *garri* samples obtained from different cultivars of biofortified cassava using different fermentation method

Cultivar	Fermentation Methods	HCN (mg/100 g)
UMUCASS 45	Traditional	0.13 ± 0.00^{e}
	Backslopping	0.13 ± 0.00^{e}
	Starter Culture	0.12 ± 0.00^{f}
UMUCASS 53	Traditional	0.10 ± 0.00^{h}
	Backslopping	0.14 ± 0.00^{cd}
	Starter Culture	0.11 ± 0.00^{g}
UMUCASS 54	Traditional	0.10 ± 0.00^{h}
	Backslopping	0.15 ± 0.00^{b}
	Starter Culture	0.13 ± 0.00^{de}
UMUCASS 45 Control	Traditional	0.14 ± 0.00^{c}
	Backslopping	0.18 ± 0.00^{a}
	Starter Culture	0.14 ± 0.00^{c}

Mean values with different superscripts along the same column are significantly different from each other (p<0.05)

CONCLUSION

The study showed that fermentation methods played significant roles in the physio-chemical properties of *garri* and in the reduction of cyanide content of biofortified cassava. From this research result, it can be concluded that the *garri* produced was within the acceptable limits of physio-chemical properties and the cyanide content, thereby making the *garri* produced safe and acceptable for human consumption. The biofortified cassava cultivars used in this study are sweet cultivars since the cyanide level was low after processing when compared with that of the white cassava cultivar; thus, biofortified cassava cultivars can be used as good substitutes for yam in making local dishes like porridge and pounded yam.

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