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Full Length Research Article

Comparative proximate and Organoleptic qualities of Garri from Newly Released Cassava Varieties (From Nextgen Cassava Project) and The Old Cassava (Tme 419)

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Abstract
Cassava is a staple food in Nigeria and many families rely on products produced from cassava. Garri is one of the products and it is a major meal for many Nigerians across the socio-economic classes. The poor nutrient compositions of the old varieties have been of great concern. The purpose of this work was to compare the garri produced from the Newly Released Cassava Varieties: Game Changer, Obasanjo-2 and Hope from the NextGen Cassava Project (implemented by IITA Ibadan & NRCRI Umudike) and old variety (TME 419). The new cassava varieties were obtained from National Root Crops Research Institute Umudike Abia State, Nigeria while TME 419 was obtained from a local farm in Umudike. The samples were tagged A, B, C & D for TME 419, Game Changer, Obasanjo-2, and Hope respectively. The percentage yield of the samples was determined and it was observed that sample A had 22 %, B 52 %, C 39 % and D 35 % ($P<0.05$). The proximate analysis showed that sample A had 347.7 energy value; 8.32 % HCN. Samples B had 351.97 energy value; 6.810 % HCN. C had 349.59 energy value, 7.475 % HCN. D had 357.16 energy value and 7.310 % HCN ($P<0.05$). The physical properties showed that in the Water Absorption Capacity, A had 4.8 g, B had 6.50 g, C 5.5g and D 5.0 g ($P<0.05$). The values of the Bulk Density were 0.60, 0.63, 0.6 and 0.61 for A, B, C and D respectively ($P<0.05$) and the Swelling Index were 3.0, 5.0, 4.5 and 4.2 for A, B, C and D respectively ($P<0.05$). The organoleptic analysis showed that sample B and C were liked very much. The newly released cassava varieties were good for production of high quality and highly acceptable garri. There is need to replace the old cassava variety with the new varieties especially Game Changer and Obasanjo 2 as the two were mostly accepted by consumers and they gave higher yield and better proximate qualities.

Keywords: NEXTGEN Cassava, Garri, Nutritional content, TME 419, Organoleptic Qualities, IITS, NRCRI

Introduction

Cassava (*Manihot esculanta* Crantz) root is one of the major root tubers produced in the forest zones of Nigeria. It is propagated by stem cutting and it is ready for harvesting and processing after a period of 12-24 months depending on the variety (Sobowale *et al.,* 2016). Cassava roots yield more carbohydrates per hectare than cereal crops and can be grown at a lower cost (Ukwuru *et al.,* 2013). It is one of the most drought tolerant crops and can be successfully grown on marginal soils, giving reasonable yields where many crops do not thrive well (FAO (2013).

It is a major source of staple food in West Africa, providing basic diet to millions of its teaming population across the different socio-economic classes (Montagnac *et al.,* 2009). Nigeria is the world largest producer of cassava with an estimated annual production of 54 million tons from an estimated area of 1.7 million hectares of land (Food and Agriculture Organisation (FAO) 2013). However, cassava roots spoil quickly after harvest due to its relative high moisture and cyanide content. In order to avoid this loss, they must be processed to other products or into dry forms that can be stored for longer periods and lower cyanide levels (Ajani *et al.,* 2016). Cassava and its products are rich in carbohydrates and are good sources of energy, a moderate source of minerals, vitamins and a poor source of proteins, in fact prominent amongst these products is garri (Montagnac *et al.,* 2009).

Botanically, cassava is a member of the family *Euphorbiaceae* and is classified as *Manihot esculenta* Crantz, formerly *Manihot utillisaima* (Okafor, 2007). It has a number of synonyms around the world: *Manioc* (Madagascar and French –Speaking Africa) *tapioca* (India, Malaysia), *Ubi Scetlela* (Indonesia) *Manioca* or *yucca* (Latin American). It has also been claimed to be a higher producer of carbohydrates than commonly cultivated cereals and tuber crops and under favourable conditions will yield above 90 tons/hectare. It is therefore not surprising that it is the staple food in densely populated areas of the tropics such as Central Java in Indonesia, the State of Kernala in India, South-Eastern Nigeria, and North-Eastern Brazil and is consumed by an estimated 400 million people around the world. Nigeria is currently the world's largest producer followed by Brazil, Indonesia, Zaire, Thailand, and Tanzania (Nweke, 1994). It is the second most important tropical root on West Africa (Falola *et al.,* 2017). Irtwange and Achimba (2009) viewed that cassava appears to be the major food that matches the population growth in Nigeria.

Deterioration which sets in immediately after harvest is a major challenge limiting commercial production of cassava (Uchechukwu–Agua *et al.,* 2015). Due to the perishability of cassava tubers, they are rapidly processed into shelf-stable products such as fufu, elubo garri etc. (Balogun *et al.,* (2012); Oyeyinka *et al.,* (2019) with low moisture content to enhance stability and long-term storage (Uchechukwu-Agua *et al.,* 2015). Among these products, garri appears to be consumed more due to its relatively longer shelf-life compared to other products from cassava as well as its ease of preparation (Oyeyinka *et al.,* 2019).

Garri is a creamy-white, partially gelatinized, roasted free-flowing granular flour made from fermented cassava roots (Sanni *et al.,* 2008). During its production, fermentation plays an important role by hydrolyzing linamarin into hydrocyanic acid at reduced

levels that may become harmless after roasting (Irtwange and Achimba, 2009; Laya *et al.,* 2018). Thus, garri is a fermented roasted granule prepared from cassava root through a series of processing steps such as: peeling, washing, grating, placing pulp in mesh bags, pressing, sieving and roasting in an open steel pan. This is either consumed immediately or further processed into various forms that combine diversity, convenience and nutritional value (Amoah *et al.,* 2009). However, in Nigeria, similar to other West African countries, higher or more than 70 % of the cassava root is processed into garri, a stable and convenient food (Achinewhu *et al.,* 1998). There were claims that newly released cassava varieties have enhanced yield, lower cyanide content, longer shelf life, increased protein content, and high dietary fibre. There was no documentation seen about quality and yield of traditional fermentation methods for garri production using these newly released cassava varieties. This research investigated and compared the proximate and Organoleptic qualities of garri produced from the new varieties by NextGen and the old one with the aim of creating awareness and advising farmers on the best variety of cassava for garri production.

Materials and Methods

Study Area

The study was carried out at the National Root Crops Research Institute (NRCRI) Umudike; Ikwuano Local Government Area of Abia State, Nigeria. It is situated along Umuahia-Ikot Ekpene Federal Road, about 8 km SE from Umuahia City Centre. The geographical coordinates are approximately 5.4761° N latitude and 7.5477° E longitude.

Experimental Design

The study adopted a Completely Randomized Design (CRD) with a single-factor treatment structure. The factor investigated was cassava variety, evaluated at four levels: TME 419 (old variety), Game Changer, Obasanjo-2 and Hope. Each cassava variety constituted a treatment and was independently processed into garri under identical conditions to eliminate processing bias. We considered the following independent variable: Cassava variety (four levels: A–D), and dependent variables: Fermentation parameters: pH and temperature (measured at 12-hour intervals for 72 hours), Processing output: percentage garri yield, chemical properties (moisture, ash, crude protein, crude fibre, fat, carbohydrate, hydrogen cyanide (HCN), and energy value), physical properties (water absorption capacity, bulk density, swelling index, peroxide value, and iodine value) and sensory attributes (appearance, colour, flavour, texture, mouthfeel, and overall acceptability).

Sample Collection

Mature cassava root tubers (18 months) of the newly released cassava varieties developed with support from NEXTGEN Cassava: Game Changer, Obasanjo-2 and Hope were obtained from the National Root Crops Research Institute (NRCRI) Experimental Farm Umudike Abia State, Nigeria. Also, TME 419 (Old Variety) mature root tubers were also obtained from a local farm within the Umudike, they were identified and authenticated by a plant taxonomist in the Department of Botany, Nnamdi Azikiwe University with the voucher number NAUH-035 (Tuber).

Sample Processing

The tubers of each sample were harvested, washed, and weighed to obtain 10.0 kg each. The weighed samples were processed into garri using the flow chart for garri production as done by Okafor (2007). The different cassava samples and their processed garri were designated with the following acronyms:

TME 419 = A

Game Changer = B
Obasanjo-2 = C
Hope = D

The cassava tubers were washed using clean water obtained from treated tap water in the Research Institute, Umudike. Peeling was done with knife sterilized with 70 % alcohol. The peeled tubers were rewashed again. The peeled and rewashed tubers were taken to the grating machine. The grating machine was thoroughly washed with detergents and clean water. The machine was rinsed with clean water before the samples of each peeled roots were fed into the machine with revolving grater and grated separately. The pulp/mash resulting from each sample was weighed and placed in mesh bags for fermentation for three days.

Measurement of pH During Fermentation
One gram (1g) of each sample (pulp from the cassava root) was collected at the intervals of twelve hours, added to 20 mls of distilled water and homogenised. The pH was measured using a portable pH meter (Jencons). This was repeated in duplicate for 3 days.

Measurement of Temperature During Fermentation
The change in temperature was measured using Hanna H199001 thermometer at the interval of twelve hours for three days.

Dewatering of the Garri Mashes
The fermented pulp of each sample was placed in mesh bags and dewatered in a hydraulic press to form cake after three days of fermentation and this drastically reduced the moisture content.

Sieving of the Caked Mashes
The caked mashes were disintegrated manually and sieved using coarse sieves (≈ 2.0–0.85 mm aperture size). The granules were collected in a basin and transferred to the fire place for garrification.

Garrification of the Sieved Granules
The sieved granules were fried with constant stirring in a flat pot on locally made oven meant for garrification in the Research Institute Umudike. Frying continued for twenty-five minutes in each case, and the fried garri were spread inside a clean room to cool.

Packaging of the Cooled Garri.
After cooling, the garri were packaged in zip lock bags and taken to the laboratory for other analysis.

Determination of Percentage of Garri yield by each cassava variety
Garri yield from the samples was determined according to the method of Sobowale *et al.* (2016). Both the garri produced and the wet cassava mash from which the garri was produced were weighed using a mettler balance (Toledo PL series-PL 6001-S).
Percentage garri yield for each sample was calculated using the formula:

$$\% \text{ garri yield} = \frac{\textit{Mass of garri produced}}{\textit{Mass of wet cassava mash that produced the garri}} \times \frac{100}{1}$$

Proximate Analysis of the Garri Samples
Proximate analysis was carried out on each of the garri samples on the following: moisture, crude protein, crude fat, crude fibre, carbohydrate, ash and cyanide contents.

The procedure for the proximate analysis used was as outlined by the Association of Official Analytical Chemist (AOAC, 2010).

Determination of Moisture Content of the Samples
Moisture content was determined according to the standard method of Association of Official Analytical Chemists (AOAC, 2010). Oven dishes were cleaned and dried in an oven at 100 ^{O}C for 1 hour to achieve a

$W_2 - W_3$ X 100

constant weight. They were cooled in a desiccator and then weighed (W_1). Two grams (2.0 g) of each sample was placed in each dish, weighed (W_2) and dried in the oven at 105 ^{O}C until constant weight was achieved. The dishes together with the samples were cooled in a desiccator and re-weighed (W_3). Percentage moisture content was calculated using the formula:

% Moisture =

Where,

W_1 = weight of dish

W_2 = weight of dish + sample before drying

W_3 = weight of dish + sample after drying

Determination of Crude Protein Content of the Samples

Crude protein was determined using the Kjeldahl method (AOAC, 2010). Two grams of garri samples from each of the cassava variety were each placed in the Kjeldahl flask. Five (5) grams of anhydrous Na_2SO_4 (Kjeldahl catalyst) was added to the flask. Twenty-five (25) ml of concentrated H_2SO_4 was added with few anti-bumping chips. The flask was heated in the fume chamber until the sample solution became clear. The sample solution was allowed to cool to 37 ^{O}C, then transferred into a 250 ml volumetric flask and made up the volume with distilled water.

The distillation unit was cleaned and assembled. Five (5) mL of 2% boric acid solution containing 3 drops of methyl red indicator was introduced into a 100 mL conical flask serving as the distillate collector). The conical flask was placed under the condenser. Then 5 ml of the sample digest was pipette into the apparatus, and wash down with 20 ml of distilled water. Five (5) ml of 60 % sodium hydroxide solution was added to the digest. The sample was heated until 10 ml of distillate was collected in the receiving flask. The content of the receiving flask was titrated with 0.02 N H_2SO_4 to a pink-coloured end point. A blank set-up was subjected to the same Then the nitrogen content was determined and protein content calculated in percentage, using the formula below:

$$\% \text{ Nitrogen} = \frac{V_S - V_B X \text{Nacid X } 0.01401 \text{ X } 100}{W}$$

Where:

V_S = vol (ml) of acid required to titrate sample

V_B = vol (ml) of acid required to titrate blank

N acid = normality of acid (0.02 N)

W = weight of samples in grams

% Crude protein = N X conversion factor

(100 % nitrogen in protein) = conversion factor (i.e. $\frac{100}{16} = 6.25$)

Where N = Nitrogen

Determination of Fat Content of the Samples

The fat content was determined using the Soxhlet extraction method according to AOAC (2010). A clean, dry 500 mL round-bottom flask was initially weighed and then filled with 300 mL of petroleum ether before being fixed to the Soxhlet extractor. Two grams (2.0 g) of the various garri samples was placed in a labeled extraction thimble, which was sealed with cotton wool. The apparatus was heated and allowed to reflux for six hours. After extraction, the thimble was carefully removed and the petroleum ether was recovered for reuse. The flask was then freed of residual solvent, dried in an oven at 105 °C for 1 hour, cooled in a desiccator, and reweighed. The increase in weight of the flask corresponded to the fat extracted, and the fat content was expressed as a percentage of the weight of the analyzed sample using the expression below:

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of Crude Fibre Content of the Samples

Crude fibre was determined using the method described by AOAC (2010). Two (2)

grams each garri sample was weighed into a 50 ml beaker and fat was extracted with petroleum ether by stirring, settling and decanting three times. The defatted sample was air dried and transferred to a 600 ml dried beaker. Then 200 ml of 1.25 % H_2SO_4 and few drops of anti-foaming agent were added to the beaker. The beaker was placed on digestion apparatus with pre-adjusted hot plate and boiled for 30 minutes, rotating beaker periodically to keep solid from adhering on the sides of the beaker. At the end of 30 minutes, the mixture was allowed to stand for one minute and then filtered through a Buchner funnel. Without breaking suction, the insoluble matter was washed with boiling water until it was free of the acid. The residue was washed back into the original flask by means of a wash bottle containing 200 ml of 1.25 % NaOH solution. It was again boiled briskly for 30 minutes with similar precautions as before. After boiling for 30 minutes, it was allowed to stand for one minute and then filtered immediately under suction. The residue was washed with boiling water, followed by 1 % hydrochloric acid and finally with boiling water until it was free of acid. It was washed twice with alcohol and then with ether for three times. The residue was transferred into ash dish and dried at 100 ^{O}C to a constant weight, cooled in a desiccator and weighed to obtain the oven-dry weight before incineration. Incineration to ash was done at 600 ^{O}C for 30 minutes, cooled in a desiccator and weighed. The difference in weight between oven dry weight and the weight after incineration was taken as the fibre content of the sample. This was expressed as a percentage weight of the original sample taken for analysis.

$$\% \text{ Crude fibre} = \frac{\text{Weight of oven dried sample} - \text{weight of sample after incir}}{\text{Weight of sample taken}} \times \frac{100}{1}$$

Determination of Ash Content of the Samples

Ash determination was carried out according to AOAC (2010) procedure. Two (2) grams of each garri sample was placed in silica dish which had been ignited, cooled and weighed. The dish and sample were ignited first gently and then at 550 ^{O}C in a muffle furnace for 3 hours, until a white or grey ash was obtained. The dish and content were cooled in a desiccator and weighed.

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} X \frac{100}{1}$$

Where,

W_1 = weight of dish

W_2 = weight of dish + sample before ashing

W_3 = weight of dish + sample after ashing

Determination of Carbohydrate Content of the Samples

The Carbohydrate was determined according to AOAC (2010), as follows:

% Carbohydrates = 100 – (% moisture + % fat + % ash + % protein + % crude fibre)

Determination of Energy Values of the Samples

The values obtained for protein, fat and carbohydrate were used to calculate the energy value of the samples using the Atwater formula as described by Onyeka (2013) and the value is expressed as kilocalories (kcal):

Protein content (%) = P

Fat content (%) = F

Carbohydrate content (%) = C

Energy value (Kcal/100g) = P × 4.0 + F × 9.0+C × 4.0

Determination of Hydrogen Cyanide (HCN) Content

This was determined by the alkaline picrate colorimetric method by AOAC (2010). Two grams of each sample was weighed into a conical flask and 200 ml of distilled water added to it. Each sample was thoroughly mixed. A stripe of alkaline picrate paper was suspended over the mixture, with the aid of

a rubber stopper, in such a way that the paper did not touch the surface of the mixture. The set up was incubated for 18 hours at room temperature. At the end of the incubation period, the picrate paper was carefully removed and placed in 60ml of distilled water. Meanwhile a standard cyanide solution was prepared and treated as described above. The absorbance of the standard and the sample were measured in a spectrophotometer at 540 nm. The cyanide content (HCN) in mg/kg was calculated using the formula:

$$HCN\ (mg/kg) = (100/W) \times Au\ (As)$$

Where,
W = weight of sample analyzed (g)
Au = Absorbance of sample (nm)
As = Absorbance of the standard HCN solution (nm)

Determination of Physical Properties

This was carried out to determine the behavioural and physical characteristics of the garri samples. The parameters determined include: Water Absorption Capacity (WAC) of the garri Samples (This was determined according to Irtwange and Achimba (2009), Bulk Density of the Samples (This was determined according to (Oluwamukomi *et al.,* 2012), Swelling Index of the garri Samples (This was determined using Sanni *et al.,* (2008), and Shelf Life of the Garri Samples (This was calculated using AOAC, (2016) method).

Assessment of the Organoleptic Qualities of the Garri Samples.

The organoleptic qualities of the garri sample were performed using twenty (20) consumers comprising males and females who were all accustomed to consuming garri. The consumers were selected from inhabitants of the National Root Crops Research Institute, Umudike Quarters. They worked under carefully controlled condition to avoid biased results. A nine-point hedonic scale point was used in the evaluation (Peryam and Pilgrim, 1957). The organoleptic attributes (appearance, colour, flavour, texture, mouth feel, and overall acceptability) were evaluated using a **nine-point hedonic scale** as described by Peryam and Pilgrim (1957), where respondents expressed their degree of liking ranging from *"like extremely"* to *"dislike extremely."* These descriptors were **coded numerically solely for ranking purposes** (e.g., 1 = like extremely, 2 = like very much, …, 9 = dislike extremely). The qualities assessed were: appearance, colour, flavour, texture, mouth feel, overall acceptability. Samples of Questionnaires were given them to rate each parameter as like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much, dislike extremely.

Mean (Average) Score of each organoleptic attribute was calculated by:

1. Sum all the numeric scores for an attribute for a sample.
2. Divide by the number of respondents (20).

Statistical Analysis.

All experiments were conducted in duplicate and data were analyzed using one-way ANOVA at 5% level of significance. Significant mean differences were separated using Least Significant Difference (LSD). All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 23.0**.**

Results

The pH of the Cassava Mash during Fermentation.

Table 1 presents the pH of different cassava mash during the period of fermentation. The pH of sample A was slightly acidic; 6.2 at the 0 hr. There was reduction in the pH from 6.2 to 4.2 at the 36 hr. the pH continued to

decrease in values resulting in increase in acidity. At the end of 72 hrs, the pH was increased to 3.8. Also in sample B, at the 0 hr, it was 5.8; 12 hr it was 5.6; the values continued to decrease hence increase in the acidity. At the 0 hr, the pH of sample C was 5.1; at 12 hrs, it was 5.8; at 72 hrs it was 3.9. In sample D, at the 0 hr, it was 6.0; 12 hrs, it was 5.5; 24 hrs, it was 5.1; and eventually at 72 hrs, it was 3.7. The pH reduced from slightly acidic in all the sample to more acidic as shown in Table 3.0.

Table 1: Mean pH of the cassava mash during the fermentation period.

Sample	Time						
	0 hr	12 hr	24 hr	36 hr	48 hr	60 hr	72 hr
A	6.2	5.6	4.5	4.2	4.0	3.9	3.8
B	5.8	5.6	5.3	4.9	4.3	4.0	3.9
C	5.1	5.8	5.4	5.1	4.5	4.2	4.1
D	6.0	5.5	5.1	4.3	4.0	4.1	3.7

Temperature of the Cassava Mash during Fermentation.

Variation in temperature of the fermenting mash were in Table 2 below. The temperature values were taken at every 12 hrs for 72 hrs. The temperatures fluctuated between this range from 25.50 – 28.10 ^{O}C. At 0 hr, the temperature was 25.50 ^{O}C in sample A and continued to increase at 12 hr and 24 hr to 26.30 ^{O}C and 27.00 ^{O}C respectively. At 36 hr, it was reduced to 26.50 ^{O}C; 48 hr it was 26.00. There was slight increase at 60 hr; 27.70 ^{O}C and decrease again at 72 hr, 27.50 ^{O}C. In sample B, at 0 hr, it was 27.00; there was increase in 12 hrs; 27.10. Decrease in temperature was observed in 24 hrs to 48 hrs; 26.50 – 25.10 ^{O}C. A slight increase was observed in 60 hr to 72 hr; 26.50 – 26.80 ^{O}C. At – 0 hr, sample C was 28.00 ^{O}C. A decrease was observed at 12 hr and 24 hr; 26.50 – 25.00 ^{O}C. An increase was observed again at 36 hr and 48 hr; 26.00 – 27.00. In sample D, at 0 hr, it was 28.10, at 12 hr, it was 27.60 and 28.00 ^{O}C at 24 hr. The temperature was observed to be 27.00 – 26.30 ^{O}C between 36 hrs – 72 hrs. The temperature fluctuated between 25.50 and 28.10 ^{O}C in all the samples as shown in table 4.0.

Table 2: Mean Temperature (^{O}C) of the cassava mash during fermentation

Sample	0 hr	12 hr	24 hr	36 hr	48 hr	60 hr	72 hr
A	25.50	26.30	27.00	26.50	26.00	27.70	27.50
B	27.00	27.10	26.50	25.00	25.10	26.50	26.80
C	28.00	26.50	25.00	26.00	27.00	25.50	26.10
D	28.10	27.60	28.00	27.00	26.00	26.30	27.00

The Percentage yield (%)

The highest garri yield (Figure 1) was obtained from Sample B (52%), followed by Sample C (39%), Sample D (35%) and least from Sample A (22%). There was significant difference in percentage yield among the four samples studied ($p < 0.05$).

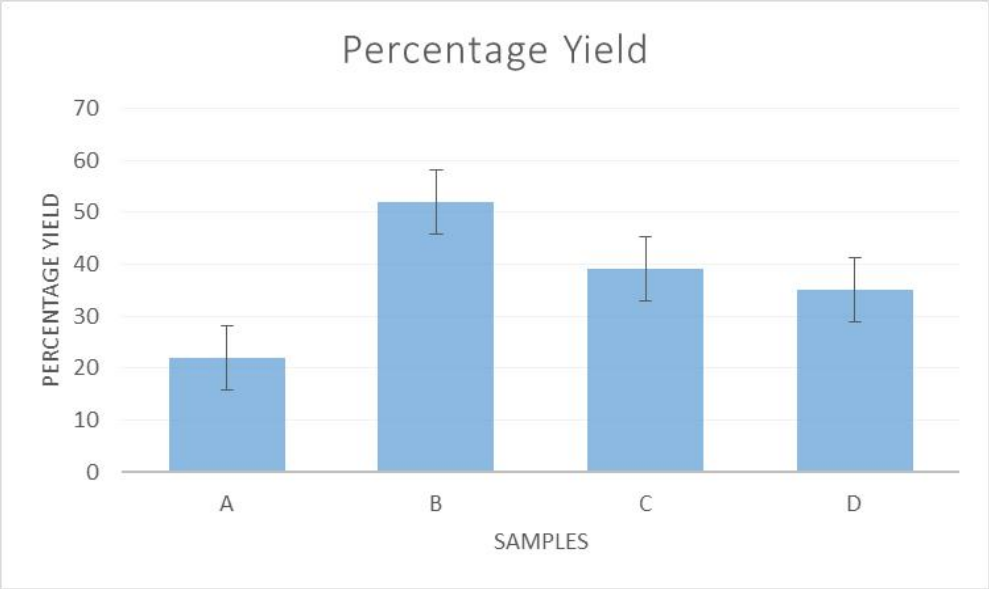


Figure 1: The Percentage yield of Garri

Proximate Analysis

The result of the proximate analysis is shown in Table 3. The findings showed that sample A had the highest percentage of moisture content, 11.76% Sample B had the least 9.86% while C and D had 10.66% and 9.76% respectively. The observed differences in moisture content among the samples were statistically significant ($p < 0.05$).

On the percentage of ash, the highest percentage is shown in sample B; 1.720%, followed by sample A; 1.645% whereas C and D had 1.585% C and 1.540% respectively. Percentage of ash contents in Sample B was statistically higher than the obtained from the other samples ($p < 0.05$).

The findings on the CP showed that sample B had the highest percentage; 5.610%. Sample A had 4.810%. Sample C had 4.910% whereas samples D had the least; 3.845%. Sample B was statistically richer in CP than in other samples ($p < 0.05$).

On the CF, sample B had the highest value 1.280% while C and D had 1.240% and 1.220% respectively. The least was observed in sample A; 1.195. Sample B was statistically richer in CF than in other samples ($p < 0.05$).

The percentage of FAT was greatest in sample C; 1.10% followed by 0.91% of Sample D, Sample B had 0.69% and was 0.75% in sample A. Sample C recorded the significantly highest percentage of FAT compared to other samples ($p < 0.05$).

For CHO, the percentage was greatest in sample D, 82.70%. Sample A had 80.90%. Sample B had 80.84% while the least percentage was observed in sample C, 7.475%. The value obtained in sample D was significantly higher than the values obtained from other Samples ($p < 0.05$).

The findings on the percentage HCN showed that Sample A had the highest value; 8.325%. Sample C had 7.475% and Sample D was 7.310%. The difference in HCN content was statistically significant ($p < 0.05$).

The energy value was highest in Sample B, 357.97. Sample D had 351.16 of energy value and C was 349.59. The least value; 347.7 was observed on sample A as shown on Table 3.0. Statistically, the energy was highest in Samples B and D, these were significantly lower that the values obtained from Samples A and C ($p < 0.05$).

Table 3: Result of the Proximate Analysis of the Samples.

SAMPLE	MC %	ASH %	CP %	CF %	FAT %	CHO %	HCN %	ENERGY VALUE
A	11.76[a]	1.645[b]	4.810[c]	1.195[b]	0.75[c]	80.90[b]	8.325[a]	347.7[b]
B	9.86[c]	1.720[a]	5.610[a]	1.280[a]	0.69[d]	80.84[b]	6.810[c]	351.97[a]
C	10.66[b]	1.585[c]	4.910[b]	1.240[a,b]	1.10[a]	79.55[c]	7.475[b]	349.59[b]
D	9.76[c]	1.540[d]	3.845[d]	1.220[b]	0.91[b]	82.70[a]	7.310[b]	357.16[a]
SE	0.025	0.00	0.005	0.002	0.014	0.053	0.042	
CV	0.2	0.0	0.1	0.1	1.7	0.1	0.6	
LSD(0.05)	0.16	0.018	0.042	0.059	0.01	0.162	0.138	

Note: values with the different superscript alphabets are down a given column are significantly different. **Key:** SE = Standard Error, CV = Critical Value, LSD = Least Significant Difference, MC = Moisture Content, ASH, CP = Crude Protein, CF = Crude Fibre, FAT, CHO = Carbohydrate, HCN = Hydrocyanide.

Physical Properties

The findings on the physical properties on Table 4 showed that Water Absorption Capacity was highest in sample B with 6.50g. Sample C had 5.5g and D is 5.0g. The least was observed in Sample A, 4.80g. The difference in water absorption capacity among garri samples from different cassava varieties was statistically significant ($p < 0.05$).

The Bulk Density of Sample B was the highest (0.63 gcm^{-3}), followed by D (0.61 gcm^{-3}). The Bulk Density of A and C are the same (0.6 gcm^{-3}). Statistically, the observed differences in Bulk Density were statistically significant ($p < 0.05$).

On the swelling index; Sample B had the highest value of 5.0 cm^3/g. C and D showed 4.5 cm^3/g and 4.2 cm^3/g respectively, whereas sample A was 3.0 cm^3/g. Statistically, differences in the values obtained were statistically significant ($p < 0.05$).

The peroxide values of B were 10 meq/kg; C was 8.0 meq/kg and D was 9.0 meq/kg while A was 3.0 meq/kg. On Iodine values, sample C had value of 10 meq/kg; sample B was 9.0 meq/kg; sample D was 11.0 meq/kg while sample A was 14.0 meq/kg as shown on Table 4. Statistically, the observed differences in both the peroxide values and iodine values among garri from the studied cassava varieties was significant ($p < 0.05$).

Table 4: The Physical Properties of the Samples

Physical properties	**Varieties of Cassava**			
	A	**B**	**C**	**D**
Water Absorption capacity (g)	4.80	6.50	5.5	5.0
Bulk Density (gcm^{-3})	0.60	0.63	0.6	0.61
Swelling Index (cm^3/g)	3.0	5.0	4.5	4.2
Peroxide Values (meq/kg)	12	10	8	9
Iodine Values (meq/kg)	14	9	10	11

Organoleptic qualities of the samples

The appearance of the cassava in group A and D was liked moderately, those of group B were liked extremely while those of group C were liked very much. However, there was a significant difference in the appearance across the four cassava samples (Table 5).

The colour of the cassava in group A were liked moderately while those of group B, C

and D were liked very much. However, there was a significant difference in the colour of among the various cassava samples (Table 5).

The flavour of the cassava in group A and D was liked moderately while those of group B and C were liked very much. However, there was a significant difference in the flavour of the cassava samples among treatments ($P<0.05$). The overall acceptability of the cassava in group A and D was liked moderately while those of group B and C were liked very much. However, there was a significant difference in the overall acceptability of the cassava across the samples (Table 5).

The texture of the cassava in group A was liked moderately while those of group B, C and D were liked very much. However, there was a significant difference in the texture across the cassava samples (Table 5). The mouth feels of the cassava in group A and D were liked moderately while those of group B and C were liked very much. However, there was a significant difference in the mouth feel of the cassava samples among treatment ($P<0.05$) as shown in Table 5.

Table 5: The organoleptic qualities of the four samples.

Samples	Organoleptic qualities					
	Appearance	Colour	Flavour	Texture	Mouth feel	Overall Acceptability
A	$2.50^{bc}\pm0.269$	$2.80^{b}\pm0.249$	$3.10^{b}\pm0.180$	$2.90^{c}\pm0.18$	$3.00^{c}\pm0.258$	$3.10^{b}\pm0.314$
B	$1.40^{a}\pm0.163$	$1.60^{a}\pm0.163$	$1.10^{a}\pm0.100$	$1.60^{a}\pm0.221$	$1.50^{a}\pm0.224$	$1.50^{a}\pm0.224$
C	$1.90^{ab}\pm0.18$	$1.60^{a}\pm0.267$	$1.20^{a}\pm0.133$	$1.80^{a}\pm0.327$	$1.90^{ab}\pm0.233$	$1.80^{a}\pm0.327$
D	$2.70^{c}\pm0.213$	$2.30^{ab}\pm0.26$	$2.70^{c}\pm0.300$	$2.40^{b}\pm0.163$	$2.60^{bc}\pm0.306$	$2.60^{b}\pm0.221$

Note: Values are mean hedonic scores ± standard error (SE) from 20 consumers.

Sensory evaluation was carried out using a 9-point hedonic scale (Peryam & Pilgrim, 1957).

Lower mean values indicate higher consumer preference.

Mean values with different superscript letters within a column are significantly different ($P < 0.05$).

Discussion

The three new varieties of cassava introduced by the NextGen Cassava Projects implemented by IITA and NCRCI were used in garri production and compared with garri from the old variety (TME419). The pH of all the fermenting cassava mash progressively decreased with increasing fermentation time, indicating a gradual increase in acidity, as shown in Table 1. This trend is attributable to microbial fermentation activities in which pyruvate serves as both an electron donor and acceptor, leading to the production of lactic acid as the major end product (Nout, 2003). The acidic environment created by lactic acid bacteria favours the proliferation of yeast. Okafor and Uzuegbu (2007) reported that *Lactobacillus* broke down starch eventually to organic acid including lactic acid. The resulting drop in pH leads to spontaneous breakdown of the linamarin and the proliferation of Fungus which produces the flavouring aldehyde, ketones and other organic compounds like esters.

Steinkraus *et al*. (2001) reported that rapid acid production is necessary and the process proceeds best at temperature of about 25 ^{0}C. Temperature is one of the factors that determines the rate of biochemical reactions. The functionality of enzymes is dependent on the temperature. The fermenting microorganisms operate best within a certain range of temperature. From Table 2.0, the range of temperature in which the microorganisms work best is 25.50 – 28.10. This is similar

as reported by Ogunsua (1980). He reported that β-linkage of linamarin can only be broken down under optimum conditions of 25 ^{o}C and pH 5.5 – 6.0.

On the yield and the suitability, these newly released cassava varieties had higher yields per unit area than the old variety. The newly released cassava varieties are reported by the NextGen Cassava Project to have higher starch content compared with old varieties. This makes it suitable for production of high-quality garri.

The proximate analysis was used for the analysis of biological materials as a decomposition of a human consumable good into its major constituents. It analyzes the macromolecules in food. Table 3.0 showed the proximate analysis of the samples; MC; ash; CP, CF, FAT, CHO, HCN and energy. The results of the proximate analysis indicated that the newly released cassava varieties had better nutritional values than the old variety.

The results of organoleptic qualities of the four samples of cassava showed that the appearance of the cassava in group A and D were liked moderately, those of group B were liked extremely while those of group C were liked very much. The overall acceptability of the cassava in group A and D were liked moderately while those of group B and C were liked very much. The combined evaluation of yield, proximate composition, physical properties, and organoleptic attributes clearly indicates the superiority of the newly released cassava varieties over the old variety (TME 419). In particular, Game Changer and Obasanjo-2 consistently demonstrated significantly higher garri yield, lower hydrogen cyanide content, improved energy values, and better functional properties such as water absorption capacity and swelling index. These attributes are critical indicators of processing efficiency and consumer desirability. Furthermore, the organoleptic assessment revealed that garri produced from Game Changer and Obasanjo-2 was liked very much by consumers, reflecting enhanced sensory appeal. The higher level of consumer acceptance, coupled with their improved nutritional and processing qualities, underscores the need for a gradual replacement of the old cassava variety (TME 419) with these improved varieties for garri production. Adoption of these varieties would not only enhance product quality but also increase productivity and economic returns for farmers.

Conclusion

This study demonstrates that the newly released cassava varieties, particularly Game Changer and Obasanjo-2, produced garri with superior yield, improved proximate composition, lower cyanide content, and higher consumer acceptability compared to the old variety (TME 419). Therefore, the replacement of the old cassava variety with these improved varieties is recommended to enhance garri quality, processing efficiency, and overall consumer satisfaction.

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Conflict of Interest

The authors declare no conflict of interest

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