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Comparison of Qualities of Garri Produced from A Mixture of Cassava Cultivars as Affected by Duration of Processing and Coloration

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Abstract
This work compared the quality characteristics of garri produced from a sample of mixed cultivars of cassava as affected by duration of processing and coloration. Harvested cassava was processed in four different forms coded AA, BB, CC, and DD. White samples are represented as W; yellow samples as Y. Highest values (in %) were recorded in white garri (19.11, AA) for Water Absorption Capacity; yellow garri (0.213, BB) for Total Titrable Acidity; white garri (3.7, BB) for pH; white garri (0.54, AA); for Hydrocyanic acid; ash content (3.22, yellow, DD); fat content at 0.71 (yellow, CC); crude fiber at 87.54 (yellow, AA); loose density at 0.680 (yellow AA); and bulk density at 0.721 (yellow, AA, sample). In all, white sample was found to contain better overall qualities.
Keywords: Cassava, coloration, cultivar, garri, processing duration.
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1.0 Introduction

Cassava (*Manihot esculenta Crantz*) is a perennial vegetatively propagated shrub grown throughout the lowland tropics for its starchy, thickened roots (Ogunyinka and Oguntuase, 2020). It is Africa's second most important food staple in terms of calories consumed per capita and a major source of calories for roughly two out of every five Africans (Ogunyinka and Oguntuase, 2020; IFAD/FAO, 2005; Rosenthal and Ort, 2012). Cassava is the raw material which is processed to produce garri,

The cassava plant is a perennial that, under cultivation, grows to a height of about 2.4 m. Its roots are tuberous, long and tapered, with firm, homogeneous flesh encased in a detachable rind, about 1 mm thick, which is rough and brown on the outside. Commercial varieties can be 5 cm to 10 cm in diameter at the top, and around 15 cm to 30 cm long. A woody cordon runs along the root's axis. The flesh can be chalk-white or yellowish. Cassava roots are very rich in starch, and contain significant quantities of calcium (50 mg/100 g), phosphorus (40 mg/100 g) and vitamin C (25 mg/100 g). However, they are low in protein and other nutrients (*Ravindran, 1992).*

Cassava has many breeds. Some are natural, while a large number of improved breeds have been developed over the years **(Egesi, 2014)**. These breeds have issues that are the targets meant to be captured in their development. Some of these include resistance to diseases, presence of vitamins and/or other nutrients, resistance to harsh or unpleasant weather, etc. **(Egesi, 2014)**. A modern farmer chooses a particular breed based on what he wants to achieve. However, subsistence farmers combine all the varieties, i.e., as much as is available. There is little or no regard to what type or special trait that is considered in his choice. Subsistence farmers make up a large percentage of cassava farmers in and around the localities here. This lapse make studying of Garri production give a little problem with clarification as no particular breed may be sustained for production.

Garri is a staple food for many people in Africa (Hahn and Keyser, 1985; Hahn *et al*., 1987). It is produced from matured harvested cassava roots by a process of peeling, grinding, pressing to dryness, and toasting. To prepare garri, fresh cassava roots are peeled, washed and grated. The resultant pulp is put in a porous sack (poly propylene bag) and weighed down with a heavy object or hydraulic press while it is fermenting. The dewatered and fermented lump of the pulp is pulverized, sifted and the resulting semi dried mash is toasted in a pan (Nweke *et al*., 2002). The final granulated product is preferred because it can be consumed dry or with cold water and/or reconstituted with hot water to form a dough which is eaten with soup (Oluwole *et* al., 2004) or stew.

The time-frame for processing of garri and coloration varies and there is no established time frame or coloration for best results. The time taken is usually a function of need, availability, and convenience. Some people can harvest and fry it the same day. Others may want to keep it till the next day, or even till the third day. In other cases, some will harvest but the processing will be the next day, and frying the third day. In any of these cases, the texture of the final product is a result of the expertise of the processor and other conditions which include the quantity of heat used in toasting, the perfection of turning while toasting, and the size of the sieve used to filter the fermented/dried cassava prior to toasting.

Fresh cassava roots cannot be stored for long because they rot within 3-4 days of harvest. They are bulky with about 70% moisture content, and therefore transportation of the tubers to urban markets is difficult and expensive (Hahn, 2010). For this reason, harvested cassava roots must be processed within a time limit of 24 – 48 hours, for best results.

Garri is usually consumed by mixing with boiling water to form a stiff paste and eaten with stews or soups as accompaniment. It may also be eaten with fried or roasted fish, coconuts, palm kernel, groundnuts when mixed with cold water, with or without the addition of sugar. Sometimes, garri is eaten dry as snack by children (Arisa *et al*., 2011). The wide consumption of garri has been attributed to its relatively long shelf life compared to other food products from cassava as well as its ease of preparation for eating (Omueti *et al.,* 1993; Sanni *et al.,* 2005).

2.0 Materials and methods

2.1 Sourcing of materials

Matured cassava roots were sourced from a local subsistence farmer from AroUmuonyeukwu village in Osisioma Local Government Area in Abia State, South-East Nigeria. The cassava roots were of varying species. This information is relevant because garri produced from these localities are usually of similar sources. The physicochemical analysis as well as the proximate analysis was carried out in the Chemistry/Biochemistry Laboratory of Abia State Polytechnic, Aba, South-East Nigeria. Other materials and equipment were also sourced from there.

2.2 Preparation of the samples

The harvested cassava roots were peeled and grated, packed in jute bags, tied and pressed with water extracting machines to remove excess water and to initiate the process of fermentation. Four (4) different sets were involved. For identification purposes, the garri samples were coded to identify the sample under test:

i. Sample harvested on Day 1, processed on Day 2, and toasted on Day 3 - Code AA.
ii. Sample was harvested, processed, and toasted on the same day - CODE BB.
iii. Sample was harvested and processed on Day 1, toasted on Day 2 - CODE CC.
iv. Harvested and processed same day, toasted on the third day - CODE DD.

White samples are represented as W, while yellow samples are represented as Y.

Each of these 4 sets was divided into two subsets. The first subset was processed as “white garri.” The second subset was processed as “yellow garri,” meaning that a quantity of red palm oil was added to it. Each set and subset was well labeled and the results of the tests were noted differently. On the whole, a total of eight samples were produced and tested on.

All the samples were made equal by sieving in a 1.00 mm sieve. The essence of this is to remove any effect of surface area on the results of the physicochemical properties such as loose density and bulk density.

2.3 Methods of physical properties determination

2.3.1 Swelling index (SI): The SI was measured using the method of Ukpabi and Ndimele (1990). Fifty grams of each garri samples were put into 500 milliliters (mL) measuring cylinders. Three hundred mL of cold water were added and allowed to stand for 4 h before observing the level of swelling. The swelling index was then calculated as the multiple of the original volume.

2.3.2 Relative Bulk Density (RBD): The RBD of the garri samples were determined by taking 5.0 g of each sample and measuring equivalent weight of 5 mL of water. Relative bulk densities were then calculated as mass of garri over the volume using a 5 mL plastic container as described by Ukpabi and Ndimele (1990).

2.3.3 Water Absorption Capacity (WAC): The WAC was determined using the method of Beuchat (1977). (1.0 g) of each garri sample was mixed with 10 mL of water for 30 sec in a mixer. The samples were then allowed to stand at room temperature for 30 min, and then centrifuged at 3,500 rpm for 30 min. The volumes of the supernatant were noted in a 10 mL measuring cylinder. The mass of water absorbed were calculated and expressed as percentages.

2.4 Physicochemical analyses of the garri samples

2.41 Loose density was calculated after gentling weighing 10 grams (g) of garri into a measuring cylinder (without tapping) and noting the volume occupied.

2.42 Bulk density was determined after tapping the cylinder containing 10g of garri samples on a table (ca. 5 min) and noting the final volume using the method described by Yusuf (2004).

2.5 Determination of proximate composition of the gari samples

2.5.1 Moisture content: The MC of each sample was determined by a modification of method described by AOAC (1990). Briefly, this was determined by weighing 5.0 g each of all the samples and drying in an oven maintained at 105°C for 7 to 8 h for a constant weight to be obtained. Thereafter, they were stored in desiccators to cool and then re-weighed. The difference in weight was used to obtain the moisture content.

2.5.2 Ash content (AC) was determined by the method described by AOAC (1990). Five grams of each sample were measured into the crucible, placed in the muffle furnace and maintained at 600/C for 6 h.
2.5.3 Crude fiber (CF) and **protein content (PC)** were determined using the method of Owoso *et al*., (2000).
2.5.4 Fat content (FC) was by soxhlet extraction method on a 5 g sample. Crude fiber content of the garri sample from each processing center was determined using method described by Pearson (1970).
2.5.5 The hydrocyanic acid (HCN) was determined using the method described by Nwabueze and Anoruoh (2009). 5.0 g of each garri sample was prepared into a paste and dissolved in 50 mL distilled water in a corked conical flask. It was allowed to stay overnight. The solution was later transferred into a conical flask. About 4.0 mL of alkaline picrate solution was added and incubated in a water bath for 5 min.
2.5.6 Total Titrable Acidity (TTA) was determined using AOAC (1990) method on a 10 g sample and Total titrable acidity was calculated as lactic acid.
2.5.7 pH Determination: The pH of each garri samples were determined using a reference electrode pH meter by homogenizing 10 g of each garri sample in 10 ml of sterile distilled water and the pH of the sample determined (Ogiehor and Ikenebomeh, 2005).

3.0 Results, discussions and conclusions

3.1 Results

FIGURE 1 is aplot of the percentage composition against sample/time for the chemical properties of the garri samples. It shows the overlapping form of the results obtained for the chemical properties of the garri sample with respect to duration of processing. The water absorption capacity (WAC) is highest for the AA sample and lowest for the CC sample for both white and yellow garri. White garri has the higher values for both. Total titrable acidity (TTA) is highest for the BB sample and lowest for the AA sample in for both white and yellow garri. The pH results for both samples are close. For white garri, the highest value is for the BB sample and lowest for the CC sample; while for yellow garri the highest AA, BB, and CC, while DD is lowest. The hydrocyanide (HCN) values have sample BB having the highest value and AA the lowest for both yellow and white garri.

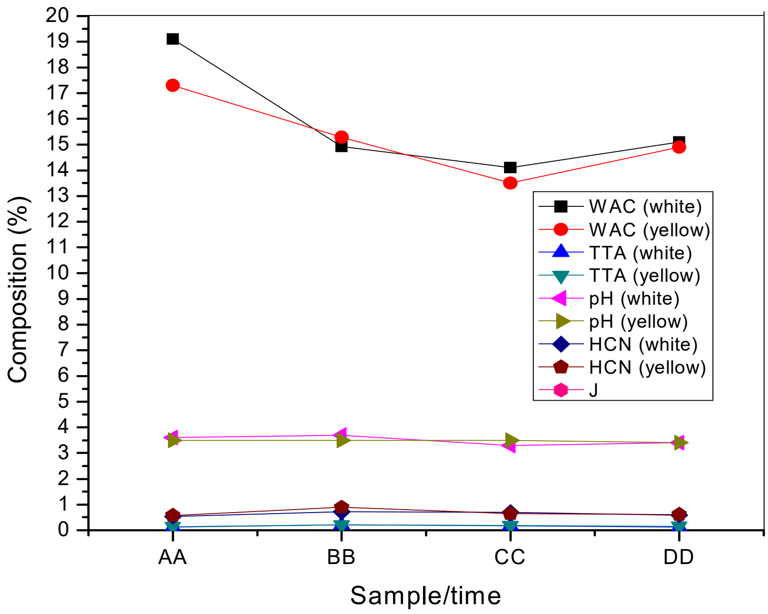


FIG. 1: Plot of % composition of chemical properties against time

In FIGURE 2, the results of proximate composition plotted against sample/time are shown. Like the results in the chemical composition, there is extensive over-lapping of the values determined and plotted against time. The highest values for moisture content (MC) are in BB and lowest in CC for both white and yellow. Ash content (AC) has highest values in DD for both white and yellow while lowest is AA for yellow and BB for white. Fat content (FC) has highest value in CC for yellow and in DD for white and lowest value and lowest value in BB for yellow garri and white garri. For crude fiber (CF), the highest and lowest values for yellow garri are in BB and CC respectively; while for white garri, they are in AA and CC respectively. Protein content (PC) has highest value in CC for yellow garri and in AA for white garri, while lowest values are in BB for yellow and white garri. The carbohydrate contents (CH) are highest in AA for yellow garri and in DD for white garri, while the lowest values are in BB for both white and yellow garri.

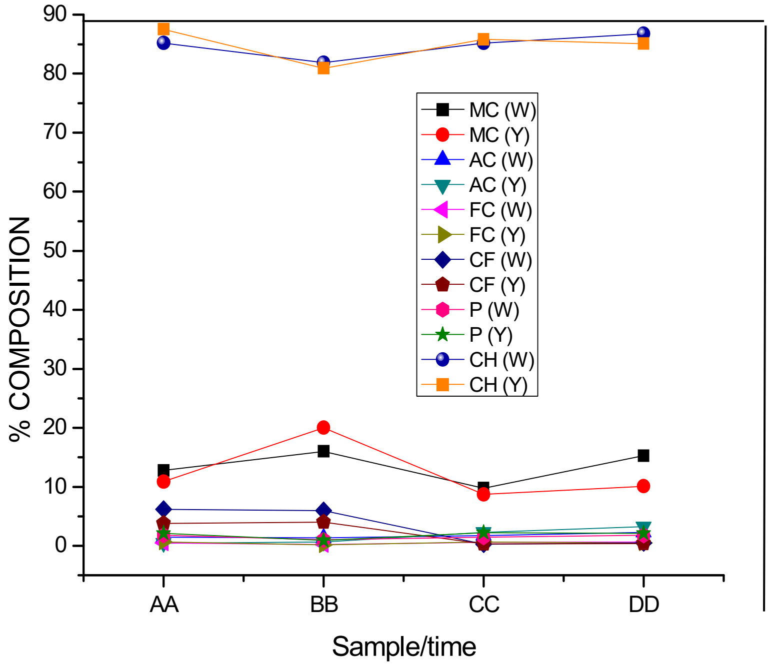


FIG. 2: Plot of % proximate composition against time

In FIGURE 3, the results from the functional physicochemical properties of the garri samples when masses (g/ml) are plotted against sample/time. The loose density (LD) is highest for the AA samples in both white and yellow garri, and lowest for the CC samples. In bulk density (BD), the AA sample has the highest value for white and yellow garri, but yellow garri has its lowest value in the DD sample while white garri has its lowest value in the CC sample. Unlike previous plots, there is no overlapping of the plots and the trends of the values are clearly elucidated.

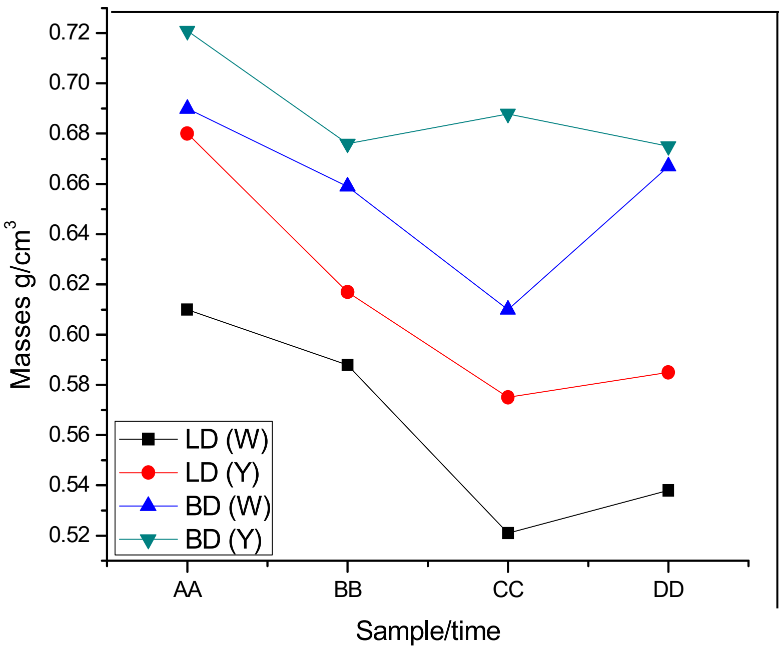


FIG. 3: Plot of functional physico-chemicals against time

Considering the results obtained from this work, it can be said that the quality characteristics of the samples produced were affected both by the duration of processing and by the addition of red oil (or not).However, samples without red oil seemed to produce better overall qualities. This is contrary to local beliefs that yellow garri is the better health-wise.

3.2 Discussions

3.2.1 Chemical properties

White garri produced overall higher values of water absorption capacity **(WAC)** with 19.11 (AA sample) while yellow garri (CC sample) produced the lowest being 13.20. The yellow sample from BB had the highest value of total titrable acidity **(TTA)** with the highest value being 0.213, and the lowest is 0.125 (DD yellow sample). All the values however, fell below the maximum of 1.0% stipulated by Garri Regulation (1980). High TTA values are an indication that the period of fermentation of is inadequate. Consequently, the conditions that gave 0.125 were best for garri production in terms of TTA.

All the garri samples are acidic with pH ranging from 3.3 to 3.7. Both extremes occurred in white gari with sample BB having the highest (3.7) and sample CC having the lowest (3.3). The acidity of fermented cassava roots and its products has been found to be caused by the synthesis of lactates, acetates and some volatile organic acids Oyewole and Odunfa, 1989). The acid contributes to the desirable sourness of gari. The sour taste is taken as an index of garri quality (Achinewhu and Owuamanam, 2001). Lower pH values therefore indicate that a product would be of a better quality and sample.The cyanide content of the samples hovered around the 0.6 % maximum stipulated by Garri Regulation (Ogunsua, 1980). Presence of cyanide above safe levels may pose health risks among consumers. Health problem referred to as Tropical Ataxic Neuropathy (TAN) reported in Nigeria (Osuntokun, 1968; Akintomiwa *et al.,* 1994) was associated with consumption of high-level cyanide in cassava-based meals. TAN has been associated with malnutrition, vitamin B deficiencies, chronic cyanide intoxication from excessive cassava consumption, tropical mal-absorption, a vegetarian diet, a poor protein intake or viral, degenerative, or genetic factors (Adamolekun, 2010). White garri AA sample had the least value at 0.54% while yellow garri BB sample was the highest at 0.89%. This could be a result of the very short period of fermentation which does not allow for the complete breakdown of the cyanorganic glycosides in cassava roots during fermentation (Komolafe and Arawande, 2010).

Considering the chemical properties of garri, the best qualities are determined as follow. For WAC, it is found in white garri (AA sample); TTA is yellow garri (DD sample); pH is white garri (CC sample), and HCN is white garri (AA sample). So for best chemical properties in garri, garri should be white (i.e., no oil added) and the processing should follow the procedure explained in code AA.

3.2.2 Proximate composition

The highest value for moisture content is white garri (15.29 %) from the DD sample, while the lowest is yellow garri (8.68) in the CC sample. Garri Regulation (1980) stipulated a maximum of 12.0 %. Moisture content is an indication of shelf life of a garri sample. The lower the moisture content, the longer the shelf life Ukpabi and Ndimele (1990). So, the yellow garri from the CC sample has the best quality in terms of moisture content.

Ash content should be 2.8% stipulated by Garri regulation (Ogunsua, 1980).. The maximum value obtained in this work is 3.22 in yellow garri from the DD sample, and the minimum is 0.67 in yellow garri from the BB sample. So, the DD yellow sample is the best in terms of ash content.

Fat content has the highest value of 0.71 in yellow garri from the CC sample making it the best quality in terms of nutritional considerations. However, low fat content is desired for longer shelf life since there is less opportunity for hydrolysis of the fat or its oxidation (Komolafe and Arawande, 2010) making the value of 0.19 found in yellow garri from the in BB sample better if shelf life is of paramount importance.

The crude fiber (CF) contents for garri samples should have a maximum level of 3.0%[26]. Garri regulation (Ogunsua, 1980) had recommended not more than 2.0%. Low fiber content is among the preferred qualities of garri (Ibe, 1981). To this end, the value of 0.31 in white garri found in the CC sample is the best quality while the value 6.2 in white garri found in the AA sample is the least quality.

The protein content of 1.79 found in white garri in the AA sample is the most desirable, while the value of 0.88 found in yellow garri from the BB sample is the least desirable.

The carbohydrate contents are all high with the best quality being 87.54 found in yellow garri from the AA sample and the least quality being 80.94 found in yellow garri from the BB sample.

So, in consideration of proximate composition values in terms of coloration and processing duration, yellow garri produced best qualities in MC (CC sample), AC (DD sample), FC (CC sample), and CH (AA sample). White garri in turn produced the best qualities in CF (AA sample) and P (AA). So, for best garri qualities in terms of proximate composition, it is recommended that oil should be added and the procedure of code AA should be followed.

3.3.3 Physicochemical properties

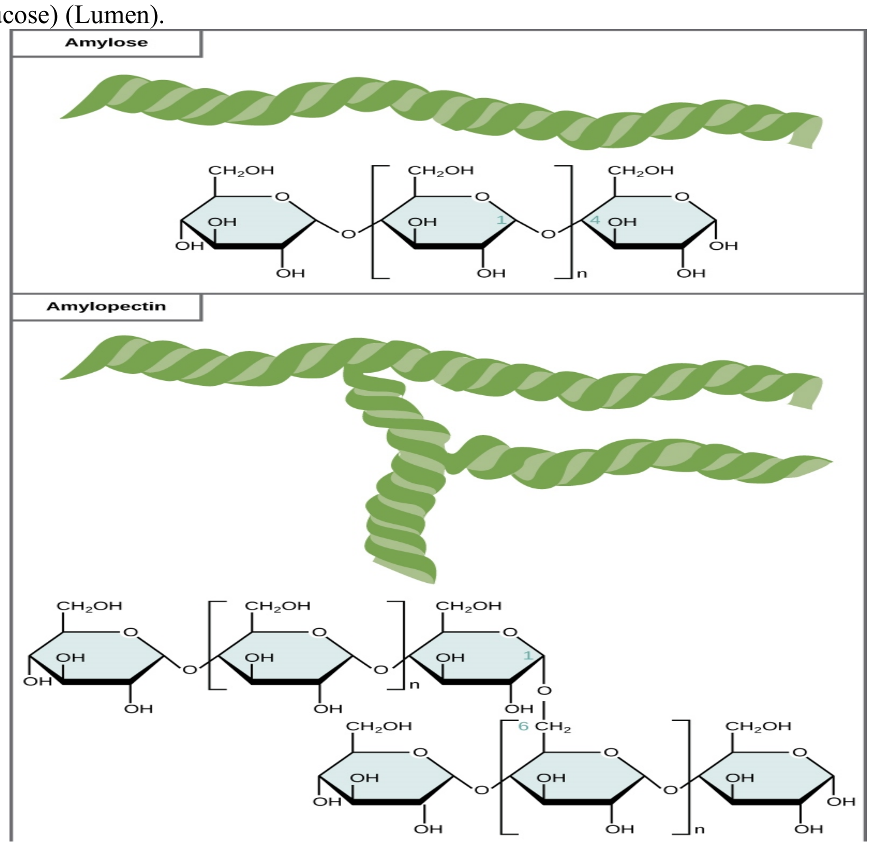
In terms of physicochemical properties, white garri of code CC sample with BD of 0.610 proved to be of the best quality considering the range of 0.50g/cm^3 to 0.91g/cm^{3}as recommended (Adindu and Aprioku, 2006). Bulk density (BD) is a reflection of the load the samples can carry if allowed to rest directly on one another. The lower the BD value, the higher the amount of garri that could be packaged in a given volume of container, thus saving space, packaging costs, and a lower transportation cost too (Komolafe and Arawande, 2010).

3.3 Conclusions

The common idea prevalent in our localities here wherein yellow garri is preferred to white garri should be more deeply investigated as it is the brand that sells more. People generally see yellow garri as more nutritious and seek for it during shopping for garri (as food). The results gotten from this work suggests that this preference may probably, be based (wholly and erroneously) on visual bias for the beautiful appearance rather than on proven nutritional dependence.

Another factor which possibly may have an effect on the quality of garri but not considered in this work is the effect of temperature on the fermentation process. Owuamanam *et al*. (2011) observed that ''increasing fermentation temperature may have enhanced optimum production of the desired organic acids and aroma precursors by microorganisms in the fermenting marsh.'' This implies that improving the quality of garri is possible if only a number of conditions such heat are improved upon during the process of processing of this staple food.

Carbohydrates, the chief nutrient in garri has been known as the major ''energy giving food'' for consumers in Western Africa and other regions of the world wherein cassava and its processed derivative are widely consumed. Starch is the stored form of sugars in plants and is made up of a mixture of amylose and amylopectin (both polymers of glucose) (Lumen).



File picture of amylose and amylopectin
(Courtesy: https://byjus.com/chemistry/amylose/)

Energy storage and food reserve are the fundamental activities of Amylose, Amylopectin, Cellulose, and Glycogen (https://byjus.com/chemistry/amylose/). Carbohydrates are covalently linked to proteins (glycoproteins) or lipids (glycolipids) and also an important part of cell membranes, and function as adhesion and address loci for cells (Aryal, 2021).

Improvements in cassava yield, quality, and sustainability could be important for food security in Africa, where the human population is expected to double by 2050 (Shackelford *et al.,* 2018; Kintché, *et al*., 2017). Such improvements in total cassava quality will spill over to the quality of garri so produced.

The applications of cassava as the raw material used for production of garri have very significant connotations. Ogunyinka and Oguntuase (2020) noted as follows: As a food crop, cassava has some inherent characteristics which make it attractive, especially to the smallholder farmers in the south-west of Nigeria. First, it is rich in carbohydrates especially starch and consequently has a multiplicity of end uses. Secondly, it is available all year round, making it preferable to other, more seasonal crops such as grains, peas and beans and other crops for food security. Compared to grains, cassava is more tolerant of low soil fertility and more resistant to drought, pests and diseases. Furthermore, its roots are storable in the ground for months after they mature.

It is recommended that further work on this topic should focus on particular cultivars for a more plain and concise comparison.

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