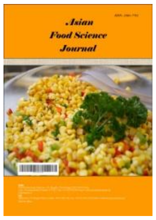

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Assessment of the Suitability of Different Cassava Varieties for Gari and Fufu Flour Production in Liberia

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Authors' contributions

This work was carried out in collaboration among all authors. Author WA did the experimental design, executed the study, analyzes the data generated and wrote the manuscript. Authors RA and WKCK contributed to the experimental design and execution. Authors AA and BMD contributed to the experimental design, laboratory analyses and writing of the manuscript. Authors AK, ME and SM contributed to sample production and collection of a representative sample for laboratory analyses. All authors read and approved the final manuscript.

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ABSTRACT

Different cassava varieties are available in Liberia, but there is little knowledge of their product suitability. Hence, the need to assess the potentials of these varieties to produce gari and fufu flour. The two products from ten improved and two local cassava varieties were characterized based on their yield and chemical, pasting and functional properties using standard methods. The results showed that TMS 96/0097 (gari 27.54%) and Butter cassava (fufu flour 27.35%) have the highest percentage yields. The starch content was higher in gari produced from TMS98/0505 (92.00%) and lower from TMS95/0289 (82.62%); the fufu flour starch content was higher in TMS98/0505 (90.59%) and lower in Bassa girl (84.75%). Gari and fufu flour produced from TMS96/0097 (507.38 RUV) and TMS00/0357 (506.04 RVU) had the highest final viscosity, and the products from TMS95/0289 (338.46 RVU and 336.80 RVU) had the least. The highest swelling power was found in gari (12.74%) and fufu flour (13.55%) produced from TMS92/0057 and the lowest in TMS91/0416 gari (8.23%) and TMS01/1235 fufu flour (8.31%). All the samples may form a paste below the boiling point of water (100°C) at < 7 min. However, cassava varieties and the interactions between varieties and locations had a significant ($P < 0.05$) effect on the properties of the products: Chemical (except ash content), pasting (except pasting temperature) and functional. Therefore, all the varieties may be suitable for gari and fufu flour production based on the quality preferred by the consumers.

Keywords: Cassava varieties; gari; fufu flour; chemical properties; pasting properties; functional properties.

1. INTRODUCTION

Cassava (*Manihot esculenta*) has been earmarked as the crop that will fast-track rural industrial development and raise income for producers, processors, and traders [1] in most sub-Saharan African countries, including Liberia. Cassava is the second most important food crop after rice and is grown throughout the country, although the area covered may vary considerably for different counties. The biological characteristics of cassava, its ability to survive after cultivation, and the viability of its cuttings have contributed significantly to its spread [2] in Liberia.

The introduction of new high yielding tropical manioc selection (TMS) varieties to most African countries by national and international research organizations has transformed cassava. From being a low-yielding crop, which used to be in the range of 7–11 t/ha on farmers' fields, it can now produce between 30 and 45 t/ha when improved agronomic practices are combined with improved varieties [3-5]. The prospects of this high yield in terms of lower production costs/ha have made cassava a crop with the potential for large-scale production, capable of being used as a cash crop for both rural and urban consumers. Differences in varieties have been reported to play essential roles in the production of diversified food products, and have significantly affected the physicochemical, functional, and other quality characteristics of fufu, gari, cassava pellets, and composite flours [6-9].

Cassava varieties are selected by farmers not only to meet their income, food security, culinary, and agronomic needs, but also from the need to preserve their cultural identity while sustaining both the high yielding varieties introduced by researchers and the high yielding local varieties. This leads to the use of different varieties to produce gari and fufu, the major cassava products consumed in almost all the counties in Liberia, but with little or no understanding of the suitability of these varieties for the products. Knowledge of the suitability of different varieties for such highly demanded products will contribute to reducing the challenge of how to balance the requirements of farmers with those of processors and end-users, mainly where there may be a compromise in productivity for varieties with the highest expression of the processor- and consumer-preferred qualities [10].

Therefore, this study is aimed at assessing the suitability of different cassava varieties for gari and fufu flour production in Liberia.

2. MATERIALS AND METHODS

Ten improved varieties (TMS01/0040, TMS96/0097, TMS95/0166, TMS95/0306, TMS00/0357, TMS91/0416, TMS01/1235, TMS92/0057, TMS95/0289, and TMS98/0505) and two local varieties (Bassa girl and Butter cassava) were obtained from the demonstration farms of the International Institute of Tropical Agriculture (IITA) in Bomi, Grand Bassa, and Gbarpolu counties. The cassava was planted in June 2016 and harvested in June 2017 (12 months), to produce gari and fufu flour.

2.1 Production of Gari

The gari samples were produced using the method described by Awoyale [11]. About 100 kg of freshly harvested cassava roots from each of the varieties and locations were peeled to remove the outer brown skin and inner thick cream layer and washed to remove stains and dirt. The peeled and washed roots were then grated, collected into woven polyethylene sacks, and fermented for three days. The fermented mash was placed on a manually operated pressing machine for dewatering. The dewatered cake was pulverized, sifted and roasted manually. The gari was allowed to cool and then packaged in polyethylene bags before laboratory analyses.

2.2 Production of Fufu Flour

The traditional method of fufu flour production was used as reported by Sanni and Akingbala [12]. The roots (100 kg) from each of the varieties and locations, were peeled using a stainless-steel knife, washed with clean water, and soaked in fermenting drums for four days. The fermented roots were then sieved through a muslin cloth and allowed to form a sediment. The sediment was collected and packed in woven polyethylene sacks and dewatered using a manually operated pressing machine. The cake was pulverized and spread on a black polyethylene sheet for drying under the sun. The dried fufu was milled using a hammer mill, cooled, and packaged in polyethylene bags before laboratory analyses.

The percentage yield of the products (gari and fufu flour) was calculated by dividing the weight of the product by the weight of the fresh roots in percentages. The yield was done for each of the cassava varieties and locations.

2.3 Chemical Composition

2.3.1 Moisture content

About 3 g of the sample was weighed into a pre-weighed, clean dried dish and placed in a well-ventilated oven (draft air Fisher Scientific Isotemp R Oven model 655F) maintained at 103 ± 2ºC for 24 hr. The loss in weight was recorded as the moisture content [13].

$$\%\ \text{moisture content} = \left(\frac{M_1 - M_2}{M_1 - M_o}\right) \times 100$$

Where

M_o = Weight in g of dish
M_1 = Weight in g of dish and sample before drying
M_2 = Weight in g of dish and sample after drying
M_1-M_o =Weight of the sample prepared for drying

2.3.2 Ash content

The sample (3 g) was weighed into a well-labeled crucible and placed in the furnace (VULCANTM furnace model 3-1750) to burn off moisture and all organic constituents at 600ºC for 5 hr. The weight of the residue after incineration was recorded as the ash content [13].

$$\%\ \text{ash content} = \left(\frac{w_3 - w_1}{w_2}\right) \times 100$$

W_3 = Weight of crucible + ash
W_2 = Weight of sample only
W_1 = Weight of crucible

2.3.3 Crude protein

The crude protein was determined by a Kjeldahl method using the KjeltecTM model 2300 protein analyzer, as described in the Foss Analytical Manual, AB. [14]. A conversion factor of 6.25 was used to convert total nitrogen to percentage crude protein (displayed on the screen of the protein analyzer).

2.3.4 Fat content

Crude fat was extracted from 3 g of the sample with hexane using a fat extractor (Soxtec System HT-2 fat extractor), and the solvent was evaporated to get the fat. The difference between the initial and final weights of the extraction cup was recorded as the crude fat content [13].

$$\%\ \text{Fat content} = \left(\frac{\text{Wt. of flask} + \text{fat} - \text{Wt. of the sample after drying}}{\text{Wt. of the sample before drying}}\right) \times 100$$

2.3.5 Starch and sugar

Finely ground sample (0.020 g) was weighed into centrifuge tubes and wetted with 1 ml of 95% ethanol. To this, 2 ml of distilled water was added, followed by 10 ml of hot ethanol. The mixture was vortexed and centrifuged (Gallenkamp model 90-1, England) at 2000 rpm for 10 min. The supernatant was collected and used for free sugar analysis; the residue was used for starch analysis [15].

$$\%\ \text{Sugar content} = \left(\frac{\text{Abs.} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume}}{\text{The weight of sample} \times \text{slope} \times 10000}\right) \times 100$$

Where:

Abs. = Absorbance; Dilution factor = 5; Volume = 20 ml

$$\%\ \text{Starch content} = \left(\frac{\text{Abs.} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume} \times 0.9}{\text{The weight of sample} \times \text{slope} \times 10000}\right) \times 100$$

Where:

Dilution factor = 20; Volume = 25 ml.

Note: The slope and intercept used for the calculations were from the standard glucose curve.

2.3.6 pH-value

Samples (5 g) were suspended in de-ionized water for 5 min at a ratio of 1:5 (w/w), and pH was measured using a digital pH meter (Orion Research Inc., USA, Model 720A) [13].

2.3.7 Cyanogenic potential content

The sample (30 g) was homogenized in 250 ml of 0.1 M orthophosphoric acid; the homogenate was centrifuged, and the supernatant was extracted. About 0.1 ml of the extract was treated with linamarin standard to get the total cyanogenic potential. Another assay was run with 0.1 ml of extract, but 0.1 ml of 0.1 M phosphate buffer (pH 6.0) was used to give the non-glucosidic cyanogenic potential. A third assay was then run with 0.6 ml of extract that was added to 3.4 ml of McIlvaine buffer (pH 4.5). It was properly mixed, and 0.2 ml of 0.5% chloramine T and 0.8 ml of color reagent were added to give the free cyanogen [16]. A standard curve was then obtained by plotting absorbance values (y-axis) against the standard concentration (x-axis): linamarin = 125 ml/ (sample weight × 0.01093); Non-glucosidic cyanogen = 125 ml/ (sample weight × 0.03176); free cyanide = 125 ml/ (sample weight × 0.04151).

2.4 Pasting Properties

The pasting properties of the samples were determined using a Rapid Visco Analyzer (RVA) (Model RVA-4C, Newport Scientific, Warriewood, Australia) interfaced with a personal computer equipped with the Thermocline Software supplied by the same manufacturer [17].

2.5 Functional Properties

2.5.1 Bulk density

About 7 g of the sample was weighed into a 50 ml graduated measuring cylinder [13]. The cylinder was tapped gently against the palm until a constant volume was obtained, and the bulk density (BD) was calculated.

$$\text{BD} = \frac{\text{Weight of sample}}{\text{The volume of the sample after tapping}}$$

2.5.2 Water and oil absorption capacities

The water and oil absorption capacities of the samples were determined using the method described by Beuchat [18].

2.5.3 Swelling power

This was determined following the method described by Leach et al. [19] with modification for small samples. A sample of 0.1 g was weighed into a weighed test tube; 10 ml of distilled water was added and heated in a water bath (Thelco, model 83, USA) at a temperature of 60ºC for 30 min with continual shaking within the heating period. In the end, the test-tube was centrifuged (Gallenkamp model 90-1, England) at 2200 rpm for 15 min to facilitate the removal of the supernatant. This was carefully decanted, and the weight of the starch paste was taken. The swelling power was then calculated.

$$\text{Swelling power} = \frac{\text{The weight of the starch paste}}{\text{The weight of the dry starch sample}} \text{ x } 100$$

2.5.4 Solubility index

The solubility index of the samples was evaluated by weighing I g into a test tube with the addition of 20 ml of distilled water. This was subjected to heating in a water bath at a temperature of 60ºC for 30 min. At the end of the heat, it was centrifuged at 2500 rpm for 20 min; 10 ml of the supernatant was decanted and dried to constant weight, and the solubility was expressed as the percentage by weight of dissolved starch from a heated solution [20].

$$\text{Solubility index} = \frac{\text{Weight of solubles}}{\text{Weight of sample}} \text{ x } 100$$

2.5.5 Least gelation concentration

The method of Coffman and Gracia [21] was used in the determination of the least gelation concentration. Appropriate sample suspensions were weighed into 5 ml of distilled water each to make 2–20% (w/v) suspensions. The test tubes containing these suspensions were heated for 1 hr in boiling water (bath) followed by rapid cooling under running tap water. The test tubes were further cooled for an hour under the running water, and the least gelation concentration was determined as the concentration when the sample did not slip or fall from the inverted test tube.

2.5.6 Dispersibility

This was determined by the method described by Kulkarni et al. [22]. Samples (10 g) were weighed into a 100 ml measuring cylinder, and distilled water was added to reach a volume of 100 ml. The mixture was stirred vigorously and allowed to settle for 3 hr. The volume of settled particles was recorded and subtracted from 100. The difference was then reported as the percentage dispersibility.

2.6 Statistical Analysis

Analysis of variance (ANOVA) and separation of the mean values (using Duncan's Multiple Range Test at $P < 0.05$) were calculated using Statistical Package for Social Scientists (SPSS) software (version 21.0).

3. RESULTS AND DISCUSSION

3.1 The Yield of Cassava Products

The knowledge of product yield (Fig. 1) is an essential physical and economic factor in screening cassava varieties for products [23]. Hence, for intending investors, TMS 96/0097 (27.54%) could be used to maximize profit for gari production and Butter cassava (27.35%) for fufu flour because these varieties have the highest percentage yield. It is important to add that apart from high dry matter content, varieties, and environment may affect product yield [24]; this is the situation in the present study. Generally, in the absence of TMS 96/0097, the use of TMS00/0357 (24.81%), TMS91/0416 (25.40%), and TMS 92/0057 (25.68%) could be profitable in gari production because their yield corresponds to the standard ratio of 1:4 [25]. That is, for every four tons of fresh cassava, 1 ton of gari is produced. Similarly, in the absence of Butter cassava, the use of TMS00/0357 (24.75%), TMS92/0057 (22.95%), TMS95/0306 (21.91%), and TMS96/0097 (25.10%) could be used profitably to produce fufu flour owing to their yield which exceeds the standard ratio of 1:5 for fufu production (Fig. 1). Also, the variations in the yields of gari and fufu flour may be attributed to an increasing difficulty in peeling, and greater losses of the pulp as peel and fiber are removed during sieving/sifting [26].

3.2 The Chemical Composition of Products from Different Varieties

The results of the chemical composition of gari (Table 1a) and fufu flour (Table 1b) produced from different varieties showed that varieties and the interactions between varieties and locations (except for ash content) had a significant ($P < 0.05$) effect on all the properties. However, the location had no significant effect ($P > 0.05$) on the protein, ash, and cyanogenic potential contents of the gari and fufu flour samples. The mean of the chemical composition of the gari produced is moisture 11.75%, starch 87.37%, sugar 3.40%, pH 4.95, protein 0.46%, fat 0.83%, ash, 0.80%, and cyanogenic potential 1.46 mg HCN/kg. Similarly, the mean of the chemical composition of the fufu flour is moisture 12.03%, starch 87.05%, sugar 3.44%, pH 4.74, protein 0.39%, fat 0.84%, ash 0.74%, and cyanogenic potential 1.69 mg HCN/kg.

Sanni et al. [27] reported that the lower is the initial moisture content of a product to be stored, the better storage stability will be. The moisture content of the gari samples ranged from 7.32 to 15.59%; gari produced from TMS95/0289 had the highest value, and that from TMS98/0505 had the lowest. Fufu flour, on the other hand, had a moisture content of between 7.31 and 15.72%, with flour from TMS95/0166 having the most and that from Bassa girl the least. This implied that gari produced from TMS98/0505 and fufu flour from Bassa girl may store longer compared with products from TMS95/0289 and TMS05/0166 because their moisture contents are lower than the 10% stipulated by the Codex Alimentarius Commission [28]. However, it is imperative to package and store products properly during marketing to avoid moisture absorption.

The starch content, which determines the texture of gari pastes, is one of the critical indices of gari quality [26]. The starch content was higher in gari produced from TMS98/0505 (92.00%) and lower in that of TMS95/0289 (82.62%). Fufu flour starch content ranged between 84.75 and 90.59%; fufu flour from TMS98/0505 had the highest and that from Bassa girl the lowest. The breakdown of the starch into sugar during gari production (fermentation) was higher in Bassa girl (4.29%) and lower in TMS01/1235 (2.78%) [26]. For fufu flour, starch breakdown into sugar was higher in the product from TMS00/0357 (4.66%) and lower in that from Butter cassava (2.85%). Surprisingly, the yield of gari from TMS95/0289 (21.62%) was higher than that from TMS98/0505 (18.66%); the yield of fufu flour was higher from Bassa girl (20.30%) and lower from TMS98/0505 (18.50%) (Fig. 1). This could be attributed to another component of the products, varietal differences, and locations.

The pH values measure the degree of acidity or alkalinity of fermented products [29]. The pH values ranged in gari samples from 4.05 to 6.55. Gari produced from TMS01/1235 had the lowest, and that from TMS95/0289 the highest. This implies that TMS01/1235 gari will be sourer when consumed than that from TMS95/0289 which may be bland in taste. Fufu flour produced from TMS95/0289 (6.45) had the highest pH value, and that from TMS01/1235 (4.14) the lowest. This means that the activity of the lactic acid bacteria is more pronounced in fufu flour produced from TMS01/1235 than in that from TMS95/0289, because of their pH values [30]. The breakdown of starch in the fresh roots by *Corynebacterium manihot* to simple sugars and the subsequent fermentation to produce lactic and formic acids may be responsible for the low pH values in some of the gari and fufu flours [31].

It is known that cassava and its products are very low in protein and fat content [32,33]. Gari from the local cassava varieties (Bassa girl and Butter cassava) had the highest protein content (0.88%), and that from TMS96/0097 (0.17%) had the lowest. The fat content was higher in gari produced from Butter cassava (1.55%) and lower in that from TMS01/0040. This variation could be due to the varietal difference. The protein content in fufu flour ranged from 0.17% (TMS95/0289) to 0.78% (TMS91/0416). The fat content of the fufu flour was higher from TMS96/0097 (1.33%) and lower in that from TMS01/0040 (0.51%).

The ash content of the gari ranged from 0.25% (TMS95/0306) to 3.61% (TMS95/0289. Fufu flour produced from Bassa girl (1.51%) was higher in ash content, and that produced from TMS95/0289 (0.25%) was lower. Ash content reflects the mineral status even though contamination during processing could indicate a high concentration in a sample [34]. The Codex Alimentarius Commission standard for ash content is 1.50% [28]. This means that gari from TMS95/0289 might have been contaminated by either the grating machine or roasting pan during processing because its ash content exceeds the stipulated value of the Codex Alimentarius Commission. The ash content of the fufu flour samples falls within the stipulated standard of the Codex Alimentarius Commission [28].

A limiting characteristic for a human that depends on cassava roots as food is the toxicity of hydrogen cyanide, which occurs because of the hydrolysis of cyanogenic glucosides, a group of nitrile-containing compounds that yield cyanide following enzymatic breakdown [35,36]. The cyanogenic glycoside is toxic to humans if the cassava is not adequately processed before consumption. Gari produced from TMS95/0166 (0.64 mg HCN/kg) had the lowest cyanogenic potential, and that from TMS92/0057 (2.52 mg HCN/kg) had the highest. The cyanogenic potential of the fufu flour ranged between 0.52 mg HCN/kg for that from TMS95/0166 and 4.15 mg HCN/kg for the product from Butter cassava. However, the cyanogenic potential of all the gari and fufu flour samples is very low compared to the Codex Alimentarius Commission's standard of 10 mg HCN/kg [28].

3.3 Pasting Properties of Cassava Products from Different Cassava Varieties

Because the gari samples may be reconstituted with hot water into *eba* and fufu flour samples may be cooked into a paste, then pasting properties become important in predicting their behavior during and after cooking [36]. The pasting properties of the gari samples showed that the mean peak viscosity is 543.56 RVU, trough viscosity 291.35 RVU, breakdown viscosity 252.20 RVU, final viscosity 416.65 RVU, setback viscosity 125.30 RVU, peak time 4.78 min, and pasting temperature 76.72 ^{o}C (Table 2a). For the fufu flour samples, the mean of the pasting properties is peak viscosity 525.06 RVU, trough viscosity 298.78 RVU, breakdown viscosity 226.28 RVU, final viscosity 430.46 RVU, setback viscosity 13.67 RVU, peak time 4.86 min, and pasting temperature 76.69ºC

(Table 2b). Additionally, varieties, location (except for trough viscosity) and the interactions between varieties and location significantly (p<0.05) affected all the pasting properties of the gari and fufu flour samples except for the pasting temperature, which was not significantly (*P* > 0.05) affected (Table 2a and 2b).

The pasting temperature is a measure of the minimum temperature required to cook a given food sample. It has implications for the stability of other components in a formulation and indicates energy costs [17]; it implies that the reconstitution of the gari produced from TMS92/0057 (60.14ºC) into *eba* may consume less energy than that from Butter cassava (84.55ºC) because of its low pasting temperature. The energy consumption for the cooking of the fufu flour produced from TMS98/0505 (72.73ºC) will be less than that from Butter cassava (84.58ºC) for the same reason. However, all the gari and fufu flour samples will form a paste below the boiling point of water (100ºC); thus, low energy will be consumed when *eba* and cooked fufu paste are produced from them. The peak time, which is a measure of the cooking time, is higher in gari produced from Bassa girl (5.57 min.) and lower in that from TMS95/0306 (4.32 min.), although all the gari samples may form a paste in less than 7 min [37,38]. Cooking the fufu flour samples into a paste may also take less than 6 min., as the peak time ranged from 4.13 min (for TMS95/0289) to 5.40 min (for Butter cassava).

Peak viscosity is the maximum viscosity developed during or soon after the heating process, which contributes to the excellent texture of the paste [39]. Thus, consumers that prefer firm-textured *eba* may use gari produced from TMS95/0306 (680.99 RVU), while those that prefer soft textured *eba* may use gari from Butter cassava (371.69 RVU). Similarly, firm-textured fufu paste may be produced from TMS95/0289 (709.71 RVU), and soft textured paste from TMS98/0505 (296.88 RVU) because of their peak viscosities.

The rate of starch breakdown depends on the nature of the material, the temperature, and the degree of mixing and shear applied to the mixture [17]. Also, the higher the breakdown viscosity, the lower is the ability of the sample to withstand heating and shear stress during cooking. Hence, gari and fufu flour produced from TMS95/0289 (406.67 RVU and 447.88 RVU) may not withstand heating and shear stress during cooking into *eba* and cooked fufu paste compared to that of Bassa girl (101.64 RVU) and Butter cassava (103.52 RVU) because of the high breakdown viscosity.

The final viscosity is the pasting parameter most commonly used to determine the quality of a starch-based sample as it indicates the ability of the material to form a gel after cooking [27]. This means that gari produced from TMS96/0097 (507.38 RUV), with the highest final viscosity, may form a gel more easily after cooking than that from TMS95/0289 (338.46 RVU) with the lowest final viscosity. Also, paste formation may be easier in fufu flour produced from TMS00/0357 (506.04 RVU) than that from TMS95/0289 (336.80 RVU) due to the high final viscosity.

The setback viscosity is the viscosity after cooling to 50ºC or the viscosity of the cooked paste. It is a stage where retrogradation or re-ordering of starch molecules occurs. Lower setback viscosity during the cooling of the paste indicates higher resistance to retrogradation [40,41]. This implies that *eba* produced from TMS95/0306 gari (74.92 RVU) may not retrograde easily because of its lower setback viscosity, compared to *eba* from TMS98/0505 gari (177.58 RVU). Likewise, cooked paste produced from TMS95/0289 fufu flour (74.96 RVU) may not retrograde easily compared to that produced from TMS01/1235 fufu flour (187.27 RVU) owing to its low setback viscosity.

3.4 Functional Properties of Products from Different Varieties

As the functional properties of foods are known to affect their end-use, how a food behaves during preparation for consumption, the water absorption capacity, oil absorption capacity, bulk density, dispersibility, swelling power, solubility index, and least gelation concentration, will be necessary to the end-users of the gari and fufu flour of the present study (Awoyale et al. 2015). The mean of the functional properties of the gari samples is water absorption capacity 358.70%, oil absorption capacity 119.19%, bulk density 53%, dispersibility 52.17%, swelling power 10.41%, solubility index 4.21%, and least gelation concentration 17.42% (Table 3a). In the same way, the mean of the functional properties of the fufu flour is water absorption capacity 356.33%, oil absorption capacity 108.56%, bulk density 55%, dispersibility 52.13%, swelling power 10.53%, solubility index 4.66%, and least gelation concentration 16.35% (Table 3b). It is important to add that the functional properties of the gari and fufu flour samples were significantly affected (p<0.05) by the varieties and location, and the interactions between them (Table 3a and 3b).

The ability to absorb water is an essential property for most starchy foods and is a function of smaller granule sizes and, thus, higher solubility [42]. The gari produced from TMS98/0505 (693.18% and 129.34%) had the highest values of the water and oil absorption capacities, and that from TMS91/0416 (140.64% and 109.50%) the lowest. This means that gari produced from TMS98/0505 may absorb more water when reconstituted into *eba* and more oil when consumed with the preferred soup because of its high water and oil absorption capacities compared with TMS91/0416 with lower values. Similarly, fufu flour produced from TMS98/0505 (669.11%) may absorb more water when reconstituted before cooking into paste compared with that of TMS95/0166 (133.89%) because of its high water absorption capacity. More oil may be absorbed by the cooked fufu paste produced from Bassa girl (127.63%) during consumption compared with paste from TMS00/0357 (95.46%) because of its high oil absorption capacity.

A measure of the minimum amount of starchy food needed to form a gel in a given volume of water is known as the least gelation concentration. The higher the least gelation concentration, the higher the amount of starch needed to form a gel; thus, a lower least gelation concentration will have a favorable economic impact on use since less starchy food would be required to make food gels [38]. Consequently, it will be more economical on the part of the consumers to use gari produced from TMS96/0097 (15.02%) for *eba* because of its lower least gelation concentration than from TMS98/0505 (20.04%), which has a higher least gelation concentration value. Likewise, fufu flour from TMS91/0416 (10.04%) may be more economical for consumers as a small quantity of the flour may give more cooked paste than that from TMS95/0166 (20.08%) because of the low least gelation concentration.

The bulk density of any product is very important in choosing the right packaging material. This is because the lower the bulk density value, the higher the amount of the product that could be packaged in each volume of the container; this will reduce the space occupied and the costs of packaging and transportation [43]. This means that more of the gari produced from TMS95/0289 (40%) may fill a smaller space in packaging materials, and thus reduce the costs of packaging materials and transport because of its low bulk density, compared to that from TMS98/0505 (70%) with a higher bulk density. Also, fufu flour from TMS95/0306 and TMS00/0357 (43%) may occupy smaller spaces in packaging materials and thus reduce the amount spent on packaging and transportation because of their low bulk density compared to TMS01/1235 (72%) with a higher bulk density.

Dispersibility is a measure of the reconstitutability of starchy foods in water. The higher the dispersibility, the better the starchy food

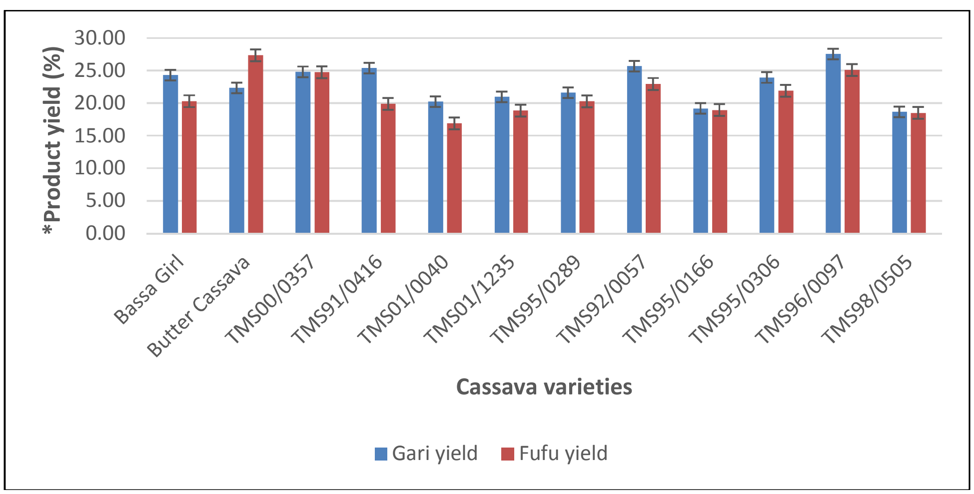

Fig. 1. The yield of gari and fufu flour produced from different cassava varieties

**The product yield is an average value for each of the cassava varieties from each location processed into gari and fufu flour*

Table 1a. Chemical composition of gari produced from different cassava varieties

	No.	Moisture (%)	Starch (%)	Sugar (%)	pH	Protein (%)	Fat (%)	Ash (%)	CNP (mg HCN/kg)
Cassava varieties									
Bassa girl	3	9.44±0.18g	85.46±1.18e	4.29±0.75a	4.85±0.01g	0.88±0.01a	0.90±0.15b-d	1.51±0.05b	1.88±0.99ab
Butter cassava	3	10.05±0.80f	88.30±0.29c	3.10±0.06e	4.74±0.09h	0.88±0.20a	1.55±0.58a	1.18±0.16b	2.33±0.75a
TMS01/0040	3	10.23±0.27f	86.46±2.24d	3.03±0.20ef	4.36±0.17i	0.62±0.33bc	0.28±0.07f	1.14±0.15b	1.86±1.43ab
TMS96/0097	3	11.60±0.87e	86.37±1.78d	3.76±0.54b	5.50±0.17d	0.17±0.00e	1.09±0.21b	0.46±0.18b	0.69±0.28b
TMS95/0166	3	14.58±1.07b	86.61±3.20d	3.49±0.76c	5.54±1.23c	0.20±0.07e	0.97±0.27bc	0.34±0.14b	0.64±0.20b
TMS95/0306	3	14.10±1.18c	91.85±0.02a	3.32±0.06d	5.09±1.14e	0.23±0.09e	0.64±0.22e	0.25±0.12b	0.65±0.06b
TMS00/0357	3	15.49±1.50a	88.58±0.90c	3.69±0.09b	5.01±0.94f	0.21±0.09e	0.93±0.11bc	0.45±0.02b	0.75±0.13b
TMS91/0416	3	13.83±0.08d	84.24±0.29f	3.44±0.04c	6.22±0.00b	0.79±0.12ab	0.69±0.06de	0.33±0.03b	0.89±0.04b
TMS01/1235	3	7.65±1.36i	86.11±0.26de	2.78±0.07g	4.05±0.14l	0.51±0.28cd	0.83±0.11c-e	0.64±0.24b	2.37±0.50a
TMS92/0057	3	8.84±0.80h	90.42±0.54b	3.08±0.13e	4.29±0.10j	0.79±0.34ab	1.02±0.13bc	0.78±0.32b	2.52±0.96a
TMS95/0289	3	15.59±0.04a	82.62±0.57g	3.35±0.08d	6.55±0.01a	0.34±0.00de	0.42±0.04f	3.61±4.53a	1.54±0.05ab
TMS98/0505	3	7.32±0.00j	92.00±7.91a	2.97±0.50f	4.19±0.01k	0.26±0.12e	0.67±0.12de	0.78±0.01b	2.48±0.62a
Location (Counties)									
Bomi	36	12.23±3.10a	86.83±2.41b	3.57±0.72a	4.95±0.87b	0.41±0.30a	0.78±0.31b	0.66±0.47a	1.31±0.95a
Gbarpolu	36	11.34±2.84c	88.68±4.62a	3.42±0.70b	4.99±0.84a	0.47±0.30a	0.80±0.31b	0.60±0.41a	1.29±1.00a
Grand Bassa	36	11.66±2.94b	86.49±2.91c	3.18±0.21c	4.92±1.08c	0.50±0.37a	0.94±0.56a	1.20±1.64a	1.82±1.01a
Mean		11.75	87.37	3.40	4.95	0.46	0.83	0.80	1.46
P Variety		***	***	***	***	***	***	**	***
P Location		***	***	***	***	NS	***	NS	NS
P Variety x Location		***	***	***	***	***	***	NS	***

*No. - Number of samples; CNP - Cyanogenic potential; NS - Not significant (P > 0.05); **P < 0.01, ***P < 0.001; Means with different letters on the same column are significantly different at P < 0.05*

Table 1b. The chemical composition of fufu flour produced from different cassava varieties

	No.	Moisture (%)	Starch (%)	Sugar (%)	pH	Protein (%)	Fat (%)	Ash (%)	CNP (mg HCN/kg)
Cassava varieties									
Bassa girl	3	7.31±0.31g	84.75±0.14g	3.18±0.06e	4.30±0.01i	0.70±0.00ab	0.90±0.07b	1.51±0.00a	1.14±0.14c
Butter cassava	3	10.30±0.03e	85.75±2.46f	2.85±0.35g	4.41±0.21h	0.53±0.14bc	0.74±0.13b-d	1.29±0.12c	4.15±2.13a
TMS01/0040	3	10.27±0.25e	86.57±2.88de	3.11±0.20ef	4.61±0.34e	0.41±0.24cd	0.51±0.43e	1.14±0.66d	1.60±0.67c
TMS96/0097	3	11.94±0.65d	87.90±3.77c	4.18±1.18b	5.09±0.74c	0.22±0.09de	1.33±0.38a	0.36±0.19gh	0.64±0.11c
TMS95/0166	3	15.72±0.20a	85.85±2.51f	3.33±0.40d	5.43±0.66b	0.26±0.10de	0.80±0.13b-d	0.40±0.17g	0.52±0.04c
TMS95/0306	3	14.18±2.80c	90.07±1.36b	4.03±0.23c	4.61±0.22e	0.26±0.10de	0.85±0.26bc	0.28±0.06hi	0.93±0.12c
TMS00/0357	3	14.08±1.37c	85.87±4.03f	4.66±0.20a	4.64±0.87d	0.35±0.14c-e	1.22±0.17a	0.31±0.06g-i	0.55±0.07c
TMS91/0416	3	7.34±0.21g	86.37±0.43e	3.19±0.06e	4.44±0.01f	0.78±0.11a	0.67±0.01c-e	1.10±0.06d	0.92±0.06c
TMS01/1235	3	7.57±0.93g	87.79±2.00c	2.92±0.27g	4.14±0.01j	0.39±0.16cd	0.71±0.09b-e	1.00±0.43e	3.04±1.09b
TMS92/0057	3	8.72±0.64f	85.72±4.77f	2.88±0.16g	4.43±0.06g	0.49±0.22c	0.90±0.10b	0.65±0.32f	3.98±1.29ab
TMS95/0289	3	15.25±0.25b	86.91±0.59d	3.07±0.04f	6.45±0.00a	0.17±0.00e	0.92±0.08b	0.25±0.14i	1.22±0.28c
TMS98/0505	3	8.45±0.01f	90.59±0.12a	3.30±0.06d	4.40±0.00f	0.68±0.00ab	0.63±0.04de	1.41±0.01b	1.60±1.58c
Location (Counties)									
Bomi	36	10.56±2.85b	86.27±3.07c	3.66±0.77a	4.97±0.63a	0.45±0.25a	0.85±0.36ab	0.74±0.56a	1.11±0.66c
Gbarpolu	36	11.91±3.30a	87.75±2.31a	3.30±0.70c	4.31±0.21c	0.37±0.16ab	0.88±0.38a	0.70±0.46b	1.78±1.60b
Grand Bassa	36	12.03±3.35a	87.13±3.50b	3.35±0.56b	4.96±0.80b	0.36±0.22b	0.79±0.17b	0.77±0.55a	2.24±1.93a
Mean		12.03	87.05	3.44	4.74	0.39	0.84	0.74	1.69
P Cassava varieties		***	***	***	***	***	***	**	***
P Location		***	***	***	***	NS	***	NS	NS
P Cassava varieties x Location		***	***	***	***	***	***	NS	***

*No. - Number of samples; CNP - Cyanogenic potential; NS - Not significant (P > 0.05); **P < 0.01, ***P < 0.001; Means with different letters on the same column are significantly different at P < 0.05*

Table 2a. Pasting properties of gari produced from different cassava varieties

	No.	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak time (min)	Pasting temp (°C)
Cassava varieties								
Bassa girl	3	373.91±12.61e	272.25±7.89c	101.66±4.72g	398.84±7.66c-e	126.59±0.23d	5.57±0.05a	83.93±3.36a
Butter cassava	3	371.69±13.55e	239.79±17.97e	131.89±29.16f	394.31±24.95de	154.52±13.80bc	5.23±0.27b	84.55±8.17a
TMS01/0040	3	486.24±77.09d	277.25±18.68c	208.99±63.39d	419.65±8.20c	142.40±12.20c	4.96±0.25c-e	76.95±1.41ab
TMS96/0097	3	671.64±3.93a	385.71±25.33a	285.94±22.83c	507.38±36.14a	121.67±11.09d	4.89±0.32de	76.16±1.58ab
TMS95/0166	3	644.76±71.35bc	288.86±45.68c	355.90±111.64b	382.97±71.65e	94.11±26.78e	4.46±0.17g	77.27±1.24ab
TMS95/0306	3	680.99±47.21a	282.96±22.14c	398.03±63.99a	357.88±38.99f	74.92±21.13f	4.32±0.06g	76.30±1.30ab
TMS00/0357	3	650.12±29.94bc	373.25±48.61a	276.88±78.50	492.90±79.62a	119.64±31.03d	4.78±0.30ef	77.58±0.87ab
TMS91/0416	3	643.12±9.02c	292.34±6.60bc	350.79±2.42b	381.71±7.01e	89.38±0.42ef	4.47±0.00g	78.33±0.04ab
TMS01/1235	3	381.06±28.08e	269.42±9.12cd	111.65±34.00g	441.77±14.22b	172.36±19.93a	4.67±0.14f	78.78±1.66ab
TMS92/0057	3	380.62±66.11e	244.83±9.22e	135.79±61.59f	408.96±6.10cd	164.12±13.18ab	5.07±0.11-d	60.14±40.15b
TMS95/0289	3	655.79±2.77b	249.00±4.13e	406.67±1.36a	338.46±5.48f	89.46±1.36ef	4.33±0.00g	78.80±0.57ab
TMS98/0505	3	482.71±6.31d	314.33±28.28b	168.38±21.98e	491.91±12.85a	177.58±15.44a	5.14±0.09bc	77.45±1.20ab
Location (Counties)								
Bomi	36	567.18±127.03a	305.56±45.52a	261.61±111.63b	420.19±59.12b	114.63±38.25c	4.80±0.43a	77.65±2.93a
Gbarpolu	36	525.41±144.92c	300.98±59.76a	224.43±116.44c	437.14±60.48a	136.16±32.37a	4.83±0.38a	79.71±4.83a
Grand Bassa	36	537.30±141.16b	264.11±36.13b	273.19±141.06a	389.20±61.91c	125.10±41.97b	4.70±0.37b	72.22±20.87a
Mean		543.56	291.35	252.2	416.65	125.30	4.78	76.72
P Variety		***	***	***	***	***	***	NS
P Location		***	NS	***	***	***	***	NS
P Variety x Location		***	**	***	***	***	***	NS

*No. - Number of samples; NS - Not significant (P > 0.05); RVU-Rapid Visco Unit; ***P < 0.001; Means with different letters on the same column are significantly different at P <0.05*

Table 2b. Pasting properties of gari produced from different cassava varieties

	No.	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak time (min)	Pasting temp (°C)
Cassava varieties								
Bassa girl	3	496.42±1.41e	259.29±3.48c-e	237.12±2.06d	421.84±3.66c-e	162.54±0.18b	4.70±0.04d-f	77.50±1.13a
Butter cassava	3	353.46±125.34h	249.94±32.11d-f	103.52±94.58h	403.08±18.87	153.14±14.94bc	5.40±0.39a	84.58±9.59a
TMS01/0040	3	411.22±100.87g	232.30±34.63f	178.92±68.12e	374.44±25.45f	142.14±16.79cd	5.00±0.12b	77.87±1.30a
TMS96/0097	3	678.23±20.73b	340.60±68.47b	337.62±68.37b	445.33±104.90b	104.73±36.58fg	4.67±0.47ef	77.36±1.21a
TMS95/0166	3	645.24±35.04d	368.20±55.65a	277.04±75.75c	486.95±86.15a	118.75±30.96e	4.77±0.26c-f	77.83±0.83a
TMS95/0306	3	666.30±17.96bc	338.96±39.36b	327.35±50.05b	435.28±56.69b-d	96.32±17.69g	4.60±0.16f	76.48±0.98a
TMS00/0357	3	652.60±10.18cd	390.77±51.68a	261.83±60.56c	506.04±83.20a	115.27±36.39ef	4.87±0.28b-e	77.33±1.62a
TMS91/0416	3	434.75±7.07f	280.12±17.15c	154.62±10.08f	414.59±0.23de	134.46±17.38d	4.97±0.05bc	78.30±0.07a
TMS01/1235	3	400.04±9.04g	266.52±11.72cd	133.52±6.29g	453.79±10.67b	187.27±20.78a	4.90±0.16b-d	78.51±0.43a
TMS92/0057	3	400.90±30.29g	237.67±11.83ef	163.23±19.22ef	390.54±13.76ef	152.88±4.18bc	4.95±0.06bc	78.30±0.07a
TMS95/0289	3	709.71±3.95a	261.83±0.35c-e	447.88±3.60a	336.80±4.07g	74.96±4.42h	4.13±0.00g	76.73±0.11a
TMS98/0505	3	296.88±6.54i	281.41±1.53c	154.60±8.08i	439.70±5.83bc	158.29±7.37b	5.37±0.52a	72.73±60.42a
Location (Counties)								
Bomi	36	527.39±144.50b	314.96±81.22a	212.43±86.04b	459.78±75.86a	144.82±30.95a	4.90±0.23a	78.28±0.66a
Gbarpolu	36	547.53±126.95a	294.88±50.40b	252.65±97.33a	412.50±48.32b	117.62±35.81c	4.78±0.30b	77.18±1.17a
Grand Bassa	36	496.74±177.90c	284.76±63.88b	211.98±152.05b	417.46±68.70b	132.70±36.71b	4.92±0.52a	74.3±22.21a
Mean		525.06	298.78	226.28	430.46	131.67	4.86	76.69
P Cassava varieties		***	***	***	***	***	***	NS
P Location		***	NS	***	***	***	***	NS
P Cassava varieties x Location		***	**	***	***	***	***	NS

*No. - Number of samples; NS - Not significant (P > 0.05); RVU-Rapid Visco Unit; **P < 0.01; ***P < 0.001; Means with different letters on the same column are significantly different at P < 0.05*

Table 3a. Functional properties of gari from different cassava varieties

	No.	Water absorption capacity (%)	Oil absorption capacity (%)	Least gelation capacity (%)	Bulk density (%)	Dispersibility (%)	Swelling power (%)	Solubility index (%)
Cassava varieties								
Bassa girl	3	543.63±0.92d	112.48±0.16e	20.03±0.01a	58.00±0.00e	31.50±0.71d	9.26±0.14e	6.10±0.02d
Butter cassava	3	579.80±3.64c	118.62±1.13cd	17.51±2.88f	55.00±0.01f	23.00±3.46g	9.56±0.29de	6.81±0.50c
TMS01/0040	3	503.85±121.30e	121.88±5.51b	16.69±2.59g	59.00±0.06d	27.83±4.92e	10.68±1.89c	4.67±1.70e
TMS96/0097	3	148.36±1.53	120.36±10.43b-d	15.02±0.01i	50.00±0.03g	75.25±2.22a	9.76±0.46d	2.57±0.19hi
TMS95/0166	3	154.32±16.90h	119.79±4.54b-d	16.68±2.59h	49.00±0.04g	74.67±1.21a	10.74±1.47c	3.05±1.14g
TMS95/0306	3	157.81±7.52g	120.66±11.19b-d	18.36±2.59c	44.00±0.03h	74.67±0.82a	11.53±0.95b	2.18±0.28j
TMS00/0357	3	239.28±128.27f	121.23±9.97bc	17.54±2.92e	44.00±0.01h	74.00±0.00a	10.65±1.59c	2.65±0.47h
TMS91/0416	3	140.64±0.18j	109.50±0.28f	15.03±0.01i	41.00±0.01i	70.00±0.00b	8.23±0.17g	2.27±0.12ij
TMS01/1235	3	581.82±3.31c	118.15±11.83d	17.53±2.90e	67.00±0.03b	41.25±6.99c	8.87±0.87f	7.76±0.25b
TMS92/0057	3	587.02±63.49b	118.45±8.24d	17.58±2.94d	62.00±0.06c	20.25±0.50h	12.74±0.37a	3.34±1.11g
TMS95/0289	3	152.25±0.42h	109.95±0.50f	20.01±0.01b	40.00±0.00i	74.00±0.00a	11.40±0.49b	4.23±0.03f
TMS98/0505	3	693.18±1.77a	129.34±0.08a	20.04±0.01a	70.00±0.00a	25.50±0.71f	8.55±0.38fg	8.23±0.25a
Location (Counties)								
Bomi	36	305.90±218.32c	111.63±3.82c	18.15±2.51a	49.00±0.08c	60.06±18.63a	9.97±1.47b	4.30±2.14a
Gbarpolu	36	382.17±195.49b	126.05±3.10a	16.90±2.51c	54.00±0.09b	50.19±25.94b	10.09±1.32b	4.21±2.20b
Grand Bassa	36	392.24±233.42a	120.00±8.09b	17.17±2.59b	55.00±0.11a	45.43±26.05c	11.27±1.68a	4.09±2.28b
Mean		358.70	119.19	17.42	53.00	52.17	10.41	4.21
P Variety		***	***	***	***	***	***	***
P Location		***	***	***	***	***	***	***
P Variety x Location		***	***	***	***	***	***	***

*No. - Number of samples; ***P < 0.001; Means with different letters on the same column are significantly different at P < 0.05*

Table 3b. Functional properties of fufu flour from different cassava varieties

Fufu products	No.	Water absorption capacity (%)	Oil absorption capacity (%)	Least gelation capacity (%)	Bulk density (%)	Dispersibility (%)	Swelling power (%)	Solubility index (%)
Cassava varieties								
Bassa girl	3	522.47±1.46d	127.63±0.36a	15.02±0.01g	52.00±0.00d	36.50±0.71e	9.07±.21g	6.86±0.06c
Butter cassava	3	517.83±9.49e	103.90±6.15e	15.04±5.75f	61.00±0.08c	31.25±0.96fg	9.19±0.18fg	6.48±0.16d
TMS01/0040	3	474.81±181.45f	115.86±7.72b	13.36±2.56i	64.00±0.07b	32.33±2.34f	12.88±0.52b	3.58±0.85fg
TMS96/0097	3	151.77±1.54j	110.93±15.20c	17.58±2.96c	48.00±0.02e	74.50±1.91ab	10.48±1.35d	3.37±1.07gh
TMS95/0166	3	133.89±9.05k	103.97±13.33e	20.08±0.06a	47.00±0.03e	75.50±0.84a	9.77±0.73e	2.28±0.66j
TMS95/0306	3	164.56±25.29h	101.62±9.26e	18.36±2.59b	43.00±0.03f	73.67±1.03bc	10.50±0.32d	2.94±0.52i
TMS00/0357	3	177.33±22.36g	95.46±2.56f	17.52±2.88d	43.00±0.02f	72.75±0.96c	10.67±0.64d	3.27±0.19h
TMS91/0416	3	522.32±0.31d	111.19±0.27c	10.04±0.01j	66.00±0.02b	31.50±0.71fg	9.56±0.06ef	7.75±0.10b
TMS01/1235	3	595.75±35.79b	117.09±0.38b	17.51±2.89d	72.00±0.02a	26.50±1.73h	8.31±0.41h	9.03±0.85a
TMS92/0057	3	561.08±32.47c	110.46±12.30c	15.11±5.80e	64.00±0.07b	30.50±1.00g	13.55±0.28a	3.68±0.28f
TMS95/0289	3	154.32±2.90i	110.39±0.14c	15.02±0.01gh	48.00±0.00e	75.50±0.71a	11.36±0.24c	5.53±0.31e
TMS98/0505	3	669.11±0.91a	107.56±0.28d	15.01±0.01h	66.00±0.02b	40.00±0.00d	8.37±0.04h	8.98±0.01a
Location (Counties)								
Bomi	36	354.75±207.83b	111.62±13.21b	16.29±3.43b	54.00±0.13b	52.88±21.69a	9.86±1.18c	4.90±2.33a
Gbarpolu	36	315.29±183.79c	101.52±9.06c	16.92±3.61a	54.00±0.10b	51.88±23.15b	10.98±1.80a	4.55±2.24b
Grand Bassa	36	405.03±239.94a	113.09±5.59a	15.75±4.31c	57.00±0.11a	51.57±21.55b	10.78±1.92b	4.50±2.52b
Mean		356.33	108.56	16.35	55.00	52.13	10.53	4.66
P Cassava varieties		***	***	***	***	***	***	***
P Location		***	***	***	***	***	***	***
P Cassava varieties x Location		***	***	***	***	***	***	***

*No. - Number of samples; ***P < 0.001; Means with different letters on the same column are significantly different at P < 0.05* reconstitutes in water [22]. This implies that gari from TMS96/0097 (75.25%) may reconstitute adequately in hot water without forming lumps when cooked into *eba*, because of its high dispersibility compared to gari from TMS92/0057 (20.25%) with lower dispersibility. In the same way, prepared paste without lumps may be produced from fufu flour from TMS95/0166 (75.50%) and TMS95/0289 (75.50%) owing to their high dispersibility values compared to TMS01/1235 (26.50%) with lower dispersibility.

The swelling power and solubility index provides evidence of the magnitude of the interaction between starch chains within the amorphous and crystalline domains. The higher the swelling power and solubility index, the lower the associative forces [44,45]. Consequently, the lower swelling power obtained in the gari sample from TMS91/0416 (8.23%) suggests a more highly ordered arrangement in its granules than in gari from TMS92/0057 (12.74%) with higher swelling power. However, a good quality gari is described as that which can swell to at least three times its original volume. This implies that gari produced from TMS92/0057 with higher swelling power may be better quality than that from TMS91/0416 with lower swelling power. The gari produced from TMS95/0306 (2.18%) might consists of highly associated starch granules with an extensive and strongly bonded micellar structure due to its lower solubility index while that of TMS98/0505 (8.23%) may be made up of weak associated forces owing to its high solubility index. The swelling power of the fufu flour ranged from 8.31 to 13.55%; TMS92/0057 fufu flour had the highest, and that from TMS01/1235 had the lowest. The solubility index of the fufu flour was higher in TMS01/1235 (9.03%) and lower in TMS95/0166 (2.28%).

4. CONCLUSION

The results of this study showed that the cassava roots varied in terms of their yield, chemical composition, and pasting and functional properties when used to produce gari and fufu flour. Varieties and the interactions between varieties and locations had a significant effect on the chemical (except ash content), pasting (except pasting temperature), and functional properties of the products. The results showed that the highest percentage yield for gari came from TMS 96/0097 (improved variety) and for fufu flour from Butter cassava (local variety). The starch content was higher in gari produced from TMS98/0505 and lowered from TMS95/0289; the starch content was higher in fufu flour from TMS98/0505 and decreased from Bassa girl. Gari and fufu flour produced from TMS96/0097 and TMS00/0357 have the highest final viscosity, and that fromTMS95/0289 has the lowest. The highest swelling power was found in gari and fufu flour produced from TMS92/0057 and the lowest in gari from TMS91/0416 and fufu flour from TMS01/1235. Therefore, all the varieties will be suitable for gari and fufu flour production, but the choice depends on the quality preferred by the consumers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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