Haya: The Saudi Journal of Life Sciences (SJLS)
Scholars Middle East Publishers
Dubai, United Arab Emirates
Website: http://scholarsmepub.com/

ISSN 2415-623X (Print)
ISSN 2415-6221 (Online)

Assessment of Some Chemical and Physicochemical Properties of *Gari* and *Pupuru* Produced from Different Varieties of Cassava

Adejuyitan JA*, Olanipekun BF, Olaniyan SA, Oyedokun RI, Oyero GO
Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Original Research Article

***Corresponding author**
Adejuyitan JA

Article History
Received: 12.05.2018
Accepted: 23.05.2018
Published: 30.06.2018

DOI:
10.21276/haya.2018.3.6.6

Abstract: The quality of food products from cassava are affected by processing methods and varieties of cassava used which may later affect consumers demand. In this work, fresh cassava roots of different local varieties (*Odongbo*, IITA *funfun*, *Olekanga*, and *Oko iyawo*) were processed into *gari* and *pupuru*. The two products were analyzed for proximate composition, mineral content, chemical and functional properties while the reconstituted meals from them were evaluated for sensory properties. The highest value of 2.13% crude protein was obtained for gari samples (*Oko iyawo* variety) while the least value was 1.80% (*odongbo* variety). For *pupuru*, the highest value was 1.70% (Oko iyawo variety) while the least was 1.52% (IITA variety). The cyanide content of gari samples from Oko iyawo had the highest value of 4.08 mgHCN/kg while *Olekanga* had the least value of 1.20 mgHCN/kg. For *pupuru*, Odongbo had the highest cyanide content of 3.31mgHCN/kg and IITA had the least value of 2.63mgHCN/kg. The mineral content showed that gari produced from IITA cassava varieties had the highest values in terms of iron, Copper and Zinc for all the cassava varieties likewise for that of pupuru except for magnesium where pupuru produced from oko iyawo cassava variety had the highest value. *Gari* samples produced from Oko iyawo cassava variety were scored highest in all the sensory parameters tested that makes the gari the most accepted whereas that of IITA cassava variety had lowest scored. Also, pupuru produced from Oko iyawo was scored highest in terms of taste and IITA cassava variety had lowest scored in terms of aroma, flavor, overall acceptability and appearance. This shows that gari and pupuru produced from IITA cassava variety were the least accepted.

Keywords: *Gari*, *Pupuru*, Cassava variety, Chemical properties, Sensory Properties.

INTRODUCTION

Cassava (*Manihot esculenta*) of the *Euphorbiaceae* (spurge) family native to South America is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous root, a major source of carbohydrates. It differs from the similarly spelled yucca, an unrelated fruit bearing shrub in *Asparagaceae* family. It is the third largest source of food carbohydrate in the tropics, after rice and maize. Cassava is a major staple food in the developing countries, providing a basic diet for over half a billion people. It is one of the most drought tolerant crops capable of growing on marginal soils. Nigeria is the world's largest exporting country of dried cassava [1]. Cassava is classified as sweet or bitter, farmers often prefer the bitter varieties because they deter pests, animal and thieves like other root and tubers, both bitter and sweet varieties of cassava contain anti-nutritional factors and toxins. It must be properly prepared before consumption. Improper processing of cassava can leave enough residual cyanide to cause acute cyanide intoxication and goiters and may even cause ataxia or partial paralysis. The more toxic varieties of cassava are fallback resources (a food security crop) in times of famine in some places. The cassava plant gives a higher yield of food energy per-cultivated area per day among crop plants, except possibly for sugarcane. Cassava roots are very rich in starch and contain significant amounts of calcium (50mg/100g), phosphate (40mg/100g) and vitamin C (25mg/100g) [2].

Cassava can be processed to tapioca, a dried powdery or pearly extract while its fermented flaky version is named *gari* [3] and other other products which include *lafun*, *fufu*, and p*upuru*. However, they are deficient in protein and other essential nutrients while cassava leaves have been proven as a good source of protein if supplemented with the amino acid, especially methionine although they contain cyanide [4, 5].

Pupuru is a fermented cassava product dried by smoking. It is commonly consumed by people living in a riverside areas of Western, Southern, Eastern and the Middle belts of Nigeria where it is also known as " ikwurikwu" [6, 7]. Opeke *et al.*, [8] reported that processing of cassava to pupuru is a major income earning venture and placed a significant role in ensuring food security for some people in Nigeria. The method of smoking the fermented cassava root makes *pupuru* processing unique as the fermented cassava mash is molded into balls and dried using smoke heat which is believed to impact some flavour characteristics and aroma to the product [6, 7]. As the increase in our population causes much demand for food, more people may have to depend on *pupuru* to supplement their carbohydrate intake [7] and also prevent monotonous consumption of other popular cassava-based foods. Currently, *pupuru* processing is entirely traditional and the product consumption is more confined to the indigenous areas [6].

Gari also known as garri or tapioca is a popular West African food made from cassava tubers. The process of making gari involves peeling of cassava, washing and grating of cassava to produce a mash. The mash is placed in a porous bag and allowed to ferment for 1or 2 days, while weights are placed on the bag to press the water out. It is then sieved and roasted by heating in a bowl. The resulting dry granular gari can be stored for long periods. It may be milled to make fine flour. *Eba* is stiff dough made by soaking gari in hot water and kneading it with a flat wooden baton. *Gari* comes in various consistencies, which can be categorized into rough, medium and smooth. Each type is used for a particular meal [6]. The goal of this work was to produce *gari* and *pupuru* from different varieties of cassava with the objectives of determining some proximate composition, mineral content, chemical, functional and sensory properties of the gari and pupuru to serve as baseline information for future references and research work.

MATERIALS AND METHODS

Materials

Cassava varieties: *Odongbo*, IITA funfun, *oko-iyawo* and *olekanga* were obtained from LAUTECH Research farm. Equipment such as cabinet dryer, milling machine, grating machine, oven, jack and sieve were used in the production of *gari* and *pupuru.*

Methods

Preparation of pupuru samples

The traditional method of pupuru production as described by Shittu *et al.*, [9] was employed. Fresh cassava roots *Manihot esculenta* of different varieties (*odongbo*, *IITA* funfun, *olekanga*, and *oko-iyawo*) were peeled and soaked for 5days, decorticated, dewatered, molded into balls and smoked dried on a raised platform laid with meshed surface constructed from raffia material locally known as "aka". The cooled pupuru was then scraped, pulverized, dried mill using hammer mill and packaged as shown in Figure-1.

Preparation of gari samples

The traditional method of producing gari as described by [10] was employed. Cassava tubers were weighed and peeled, after peeling, the cassava tubers were washed and then grated to produce a mash. The mash was placed in a porous bag and allowed to ferment for 72 h. It was dewatered through the use of hydraulic press, toasted, cooled, sieved and packaged.

Analysis of the samples

The proximate compositions were determined according to the standard of AOAC [11], carbohydrate was calculated by difference. pH, titratable acidity, residual cyanide content and swelling capacity of gari and pupuru were analysed following the procedure of AOAC [11]. Water absorption capacity was carried out using the procedure of Owuamanam *et al*., [12] and bulk density was determined by using the method of [13]. Minerals (Cu, Zn, Mg and Fe) were analyzed using the dry-ashing technique according to AOAC [11]. Sensory evaluation of the gari and pupuru were determined using nine point hedonic scale ranging from 9= like extremely to 1= dislike extremely was used by trained panelists for the following attributes: taste, flavor/aroma, appearance, texture/particle size and overall acceptability.

RESULTS AND DISCUSSION

Proximate composition of the gari and pupuru

The results of the proximate composition of the gari and pupuru samples are presented in Table-1. The values for the moisture content ranged from 9.16% -10.52% with the gari produced from odongbo cassava variety having the highest value (10.52%) and gari produced from IITA cassava variety having the lowest value of (9.16%). Pupuru produced from odongbo cassava variety had the highest moisture content value of 9.79%, while pupuru produced from Olekanga had the lowest moisture content value of 8.74%. There was significant difference ($p<0.05$) between the moisture content of the cassava products (gari and pupuru) produce from different varieties of cassava. The gari and pupuru samples had low moisture contents which are within the range of values reported for sweet potato-gari by [14]. Irtwanga and Achimba [15] stated that good quality gari should be well dried and thus of low moisture content to enhance proper storage and increase the shelf life. Odetokun *et al*., [16] reported 9.86 and 10.20% for traditional prepared pupuru. Frying method and time can affect the amount of moisture retained in the samples.

The maximum value for crude fibre was 2.27% for gari while the minimum value was 1.69%. For pupuru, the maximum value was 2.03%, while the minimum value was 1.27% as presented in Table-1. There was significant difference ($p<0.05$) between gari and pupuru samples produced from different cassava varieties. This difference could be associated with varietal differences in the materials used. However, the range of values observed in this study agrees with those reported for gari produced from cassava by Irtwanga and Achimba [15].

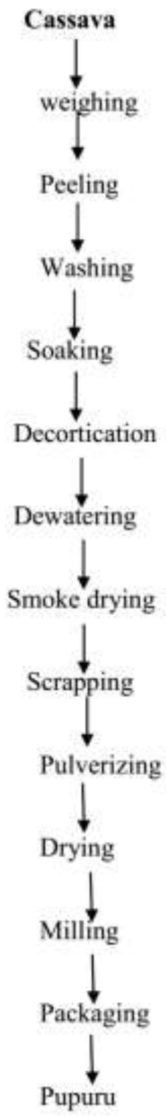

Fig-1: Flow chart of pupuru processing

Table-1: Proximate Composition (%) of gari and pupuru produced from different cassava

Samples	Moisture	Protein	Ash	Fat	Fibre	Carbohydrate
Gari						
Odongbo	10.52±0.08^{d}	1.80±0.01^{a}	1.19±0.08^{a}	1.78±0.08^{b}	2.27±0.10^{b}	82.44±0.16^{a}
IITA	9.16±0.01^{a}	1.97±0.01^{b}	1.63±0.18^{b}	1.63±0.06^{b}	2.01±0.09^{ab}	83.62±0.01^{b}
Olekanga	10.27±0.01^{c}	1.86±0.06^{a}	1.44±0.05^{ab}	1.31±0.00^{a}	1.69±0.10^{a}	83.43±0.05^{ab}
Oko iyawo	9.40±0.14c^{b}	2.13±0.03^{c}	1.55±0.08^{b}	1.10±0.13^{a}	1.75±0.36^{ab}	84.07±0.48^{b}
Pupuru						
Odongbo	9.79±0.11^{c}	1.58±0.03^{ab}	0.77±0.06^{a}	0.78±0.13^{b}	1.27±0.05^{ab}	85.77±0.16^{b}
IITA	9.40±0.13^{b}	1.52±0.01^{a}	1.79±0.07^{c}	1.07±0.26^{c}	2.03±0.09^{c}	84.16±0.01^{a}
Olekanga	8.74±0.15^{a}	1.64±0.20^{ab}	1.04±0.11^{b}	0.53±0.10^{a}	1.31±0.05^{a}	86.94±0.06^{c}
Oko iyawo	9.29±0.03^{b}	1.70±0.09^{b}	1.19±0.06^{b}	0.86±0.08^{b}	1.38±0.13^{b}	85.58±0.16^{b}

Values are means of three determinations.

Means with the same superscript along the same column are not significantly different ($p<0.05$).

The crude fibre of pupuru samples was slightly lower than that of gari samples. Olaleye [17] reported that crude fibre and ash contents depend on the quality of fresh roots and processing techniques. Also, Fasuyi and Aletor [18] claimed that good quality fresh cassava roots which are clean and have minimal or no stem or woody parts will produce cassava roots products with low crude fibre and ash contents. Ash content showed significant different ($p<0.05$) from each other (gari and pupuru). Gari produced from IITA cassava variety had the highest ash content of 1.63 %, while gari produced from odongbo cassava variety had the lowest value of 1.19%. For pupuru, IITA variety had the highest value of 1.79%, while the one produced from *odongbo* cassava variety had the least value of 0.77%. The ash contents of gari samples were slightly higher than that of pupuru except for the products from IITA cassava variety where the value of pupuru was higher than that of gari. These variations can be as a result of the findings reported by Olaleye [17] and Fasuyi and Aletor [18]. High ash content is advantageous since the ash content is the reflection of the mineral contents of the products.

Also, the highest value of crude protein obtained for gari samples were 2.13% (oko iyawo gari) while the least was 1.80% (odongbo gari). For pupuru, the highest value was 1.70% (oko iyawo pupuru) while the least was 1.52% (IITA pupuru). Irtwange and Achimba [15] gave the crude protein content of their gari in the range of 2.33 to 2.55%. Komolafe and Arawande [19] gave protein contents of gari samples in the range of 1.04 to 1.40%. According to Obatolu and Osho [20] gari should contain 0.7 to 1.2% protein. The protein contents in this study are higher than the ones reported by previous researchers except for that reported by Irtwange and Achimba [15]. Olaleye [17] reported that fermentation of cassava roots result in protein enrichment, which might be the reason while the values of crude protein content for gari was slightly higher than that of pupuru.

The range of values for crude fat for gari falls between 1.10% and 1.78% with gari produced from odongbo cassava variety having the highest and gari produced from oko iyawo cassava variety had the least. For pupuru the values of crude fat ranges between 1.07% and 0.53% with pupuru produced from IITA cassava variety having the highest, while pupuru produced from olekanga cassava variety had the lowest. The fat content of gari samples was higher than that of pupuru samples. The significant difference ($p<0.05$) in the fat content value of gari and pupuru could be as a result of varietal differences [21]. Processing technique can also be another reason for the difference in the fat content value between gari and pupuru. During soaking of cassava for pupuru production most of the nutrient must have being lost into the soaking water.

Carbohydrate values for gari samples ranges from 84.07% to 82.44% with gari produced from oko iyawo cassava variety having the highest and that produced from odongbo cassava variety had the least. For pupuru carbohydrate value ranges from 84.16% to 86.94% with pupuru produced from olekanga cassava variety having the highest and that produce from IITA cassava variety having the least. Carbohydrate content of pupuru samples was higher than that of gari samples. Significant differences ($p<0.05$) were observed among the carbohydrate values for the gari and pupuru samples. This might be as a result of the high protein, ash, fat and crude fibre values of gari relative to that of pupuru samples.

Chemical properties of gari and pupuru

The chemical properties of gari and pupuru produced from four different varieties of cassava roots (Odongbo, IITA, Olekanga and Oko iyawo) are as shown in Table-2. The pH ranges from 4.13 to 4.36 for gari and 4.50 to 4.74 for pupuru. Gari produced from odongbo had the least pH value (4.13) while gari produced from oko iyawo had the highest (4.36). The pH increased in this order odongbo > IITA > olekanga > oko iyawo. Pupuru produced from olekanga had the least pH value of 4.50 while pupuru produced from IITA had the highest value of 4.74. pH of pupuru increased in this order olekanga > oko iyawo > odongbo >IITA. pH is an important parameter in determining the quality of cassava flour since pH of 4 or less indicates appreciable level of fermentation, low level of acidity and hence starch breakdown [22]. Fermentation imparts characteristic aroma, flavour and sour taste to gari and pupuru. The gari and pupuru had pH values ranging between 4.13 to 4.36 and 4.50 to 4.74 respectively, indicating that they were of good qualities. pH was not significantly affected ($p>0.05$) by varietal difference.

Table-2: Chemical Composition of Gari and Pupuru Produced from Different Cassava varieties

Samples	pH	TTA (%)	Cyanide content (mgHCN/kg)
Garri			
IITA	4.13	0.914 ± 0.002^{c}	2.32 ± 0.03^{c}
Olekanga	4.24	0.811±0.001b	1.32 ± 0.04^{b}
Oko iyawo	4.35	0.719 ± 0.001^{a}	1.20 ± 0.03^{a}
Odongbo	4.36	1.061 ± 0.002^{d}	4.08 ± 0.06^{d}
Pupuru			
IITA	4.74	0.378 ± 0.002^{a}	2.63 ± 0.04^{a}
Oko iyawo	4.64	0.476 ± 0.001^{b}	2.82 ± 0.03^{b}
Odongbo	4.66	0.494 ± 0.002^{c}	3.31 ± 0.03^{d}
Olekanga	4.50	0.522 ± 0.002^{d}	3.06 ± 0.03^{c}

Values are means of three determinations.

Means with the same superscript along the same column are not significantly different ($p<0.05$).

Titratable acidity of the gari and pupuru samples ranged from 0.72 to 1.06 and 0.38 to 0.52, respectively. The titratable acidity of pupuru was considerably lower in comparison to that of gari. The highest value for pupuru was 0.52 while the least for gari was 0.72 which shows that the least titratable acidity value for gari was higher than the highest value for pupuru. The TTA for gari and pupuru decreased in the order oko iyawo > odongbo > IITA > olekanga and olekanga > odongbo > Okoiyawo > IITA, respectively. Hence the varying TTA values of some of the products might be due to loss of some volatile components like hydrocyanic acid (HCN) produced from the hydrolysis of the cyanoglucoside [17]. It can also be due to varying level of dissociation of the weak organic acids mainly lactic and formic acid [23]. Titratable acidity (TTA) was significantly affected ($p>0.05$) by varietal difference.

The cyanide content of gari ranges from 1.20mg/kg to 4.08mg/kg while that of pupuru ranges from 2.63mg/kg to 3.31mg/kg. For gari samples oko iyawo had the highest cyanide content of 4.08mg/kg, while olekanga had the least value of 1.20mg/kg. Pupuru produced from odongbo had the highest cyanide content of 3.31mg/kg and IITA had the least value of 2.63mg/kg. The results are within the 2-3 mg HCN/100g regarded as acceptable level of cyanide in gari [24]. Cyanide is very poisonous because it binds cytochrome oxidase and stops its action in the electron transport chain, which is a key energy conversion process in the body, excess cyanide content in cassava products could have deleterious effects on the consumer. Non-fatal amounts of cyanide cause acute intoxication with symptoms of dizziness, headache, stomach pains, vomiting and diarrhea [25]. Processing method affects the residual content of cyanide in cassava product as previously reported by Enidiok *et al.*, [26] which shows that fermentation period had effect on the breakdown of cyanogenic glucosides in the cassava pulp as well as leaching out of HCN along with the cassava fluid.

Odoemelam [27] also reported that the longer the fermentation period, the lesser the residual cyanide content in the final gari product. Also, O'Brien *et al*., [28] reported that the variation in the cyanide concentration of the individual gari samples can be attributed to the differences in the cassava cultivars. The values obtained for gari and pupuru (cassava products) are lower than the safe level of 10mg/kg recommended by the Food and Agricultural Organization (FAO) and World Health Organisation (WHO) according to Adindu *et al*., [29]. Since the values obtained for all the gari and pupuru samples are below the safe level, the products can therefore be considered adequate and safe for human consumption as regards cyanide poisoning.

Mineral Composition of *gari* and *pupuru* produced from different cassava varieties.

The results of the mineral composition of the gari and pupuru samples are presented in Table 3. The iron content in gari ranges from 0.118 part per million (ppm) to 0.159 ppm with gari produced from IITA cassava variety having the highest and gari produced from oko iyawo having the least value. For pupuru, it ranges from 0.093 to 0.120 ppm with pupuru produced from IITA cassava variety having the highest and the one produced from odongbo variety the least. Gari produced from IITA had the highest copper content while the one produced from oko iyawo had the least copper content. For pupuru, the one produced from IITA had the highest while pupuru produced from odongbo and oko iyawo had the least copper content. The zinc content for both gari and pupuru were significantly difference ($p<0.05$) with gari and pupuru produced from IITA cassava variety having the highest of 0.088 and 0.076 ppm respectively. There was no significant different ($p<0.05$) in the magnesium content of gari while there was significant difference ($p<0.05$) in that of pupuru produced from oko iyawo cassava variety having the highest value of 0.217 ppm and the one produced from odongbo the least with 0.132ppm.

The mineral contents of pupuru samples were generally lower than that of the gari samples. Also, the soaking of cassava for pupuru making might be the reason for the reduction (minerals leach into water during soaking). Gari produced from IITA cassava varieties had the highest minerals content of all the varieties likewise for pupuru except for magnesium where pupuru produced from oko iyawo cassava variety had the highest. The result of the mineral composition shows that varieties of cassava and processing methods had significant effects on the mineral composition of the cassava products (gari and pupuru).

Functional properties of the gari and pupuru samples

The bulk density of gari and pupuru samples varied between 0.69g/cm^3 to 0.74g/cm^3 and 0.79g/cm^3 to 0.85g/cm^3, respectively as shown in Table-4. Gari sample produced from oko iyawo had the highest bulk density while gari produced from IITA variety had the least bulk density. For pupuru, sample from olekanga had the highest while the sample produced from IITA had the least value. The bulk density result of all the gari samples produced from different varieties of cassava root was desirable and fell within acceptable range of 0.50g/ cm^3 to 0.91g/ cm^3 as reported by Adindu and Aprioku [29]. Komolafe and Arawande [19] gave the bulk density of 0.55 g/cm^3 to 0.82 g/cm^3 for gari samples from cassava. According to Ukpabi and Ndimele [30], good gari should have bulk density of 0.56 g/cm^3 to 0.908 g/cm^3. Udensi *et al*., [31] reported that high bulk density increases the rate of dispersion of granule in water which is important in the reconstitution of flours in hot water to produce dough.

There was a significant ($p<0.05$) difference in the bulk density values of gari and pupuru produce from different varieties of cassava roots.

Table-3: Minerals Composition of gari and pupuru produced from different cassava varieties

Samples	Iron (Fe) (ppm)	Copper (cu) (ppm)	Zinc (Zn) (ppm)	Magnesium (Mg) (ppm)
Gari				
Odongbo	0.128 ± 0.0003^{ab}	0.091 ± 0.0004^{b}	0.062 ± 0.0019^{a}	0.192 ± 0.0011^{a}
IITA	0.159 ± 0.0006^{c}	$0.123 \pm 0.0s003^{d}$	0.088 ± 0.0018^{c}	0.220 ± 0.0011^{a}
Olekanga	0.133 ± 0.0086^{b}	0.119 ± 0.0004^{c}	0.075 ± 0.0007^{b}	0.160 ± 0.0570^{a}
Oko iyawo	0.118 ± 0.0004^{a}	0.071 ± 0.0001^{a}	0.058 ± 0.0010^{a}	0.190 ± 0.0004^{a}
Pupuru				
Odongbo	0.093 ± 0.0008^{a}	0.070 ± 0.0003^{a}	0.062 ± 0.0007^{c}	0.132 ± 0.0030^{a}
IITA	0.120 ± 0.0003^{d}	0.440 ± 0.5100^{a}	0.076 ± 0.0004^{d}	0.176 ± 0.0003^{c}
Olekanga	0.096 ± 0.0004^{b}	0.083 ± 0.0003^{a}	0.038 ± 0.0003^{a}	0.140 ± 0.0016^{b}
Oko iyawo	0.099 ± 0.0010^{c}	0.070 ± 0.0003a	0.059 ± 0.0004^{b}	0.217 ± 0.0006^{d}

Values are means of three determinations.
Means with the same superscript along the same column are not significantly different ($p<0.05$).

Table-4: Functional properties of gari and pupuru produced from different cassava varieties

Sample	Water absorption capacity(WAC) (ml/g)	Swelling capacity	Bulk density(g/cm³)
Gari			
Odongbo	4.07 ± 0.12^{a}	3.58 ± 0.02^{b}	0.72 ± 0.02^{ab}
IITA	4.50 ± 0.00^{b}	3.91 ± 0.03^{c}	0.69 ± 0.01^{a}
Olekanga	4.40 ± 0.00^{b}	4.01 ± 0.02^{d}	0.72 ± 0.01^{ab}
Oko iyawo	4.00 ± 0.00^{a}	3.32 ± 0.03^{a}	0.74 ± 0.01^{b}
Pupuru			
IITA	3.87 ± 0.15^{b}	3.04 ± 0.02^{d}	0.79 ± 0.01^{a}
Oko iyawo	3.67 ± 0.06^{b}	2.03 ± 0.02^{a}	0.80 ± 0.01^{a}
Odongbo	3.07 ± 0.06^{a}	2.20 ± 0.00^{b}	0.81 ± 0.01^{a}
Olekanga	4.17 ± 0.06^{c}	2.80 ± 0.02^{c}	0.85 ± 0.01^{b}

Values are means of three determinations.
Means with the same superscript along the same column are not significantly different ($p<0.05$).

The swelling capacity of the samples ranged from 3.32 to 4.01 for gari and 2.03 to 3.04 for pupuru. The swelling capacity of pupuru samples was lower to that of gari samples. Olaleye [17] reported that starch with large granules display higher swelling power than starch with small granule. The gari produced from olekanga cassava varieties had the highest swelling capacity value of 4.01 while the gari produced from oko iyawo cassava variety had the least swelling capacity value of 3.32. Pupuru produced from IITA cassava variety had the highest swelling capacity of 3.04 while that of oko iyawo cassava variety had the least swelling capacity of 2.03. The varieties of cassava used in producing the gari and pupuru caused a significant ($p<0.05$) difference in their swelling capacities. According to Udensi *et al.*, [31] high swelling capacity was shown to give a greater volume and more feeling of satiety per unit weight of gari. Swelling capacity is one of the important quality criteria as it indicates the degree of gelatinization of the gari and pupuru.

Also, the water absorption capacity of gari samples ranged from 4.00ml/g to 4.50ml/g with gari produced from IITA cassava variety having the highest value of 4.50ml/g and gari produced from oko iyawo cassava varieties having the lowest value of 4.00ml/g. For pupuru samples, the water absorption capacity ranges from 3.67ml/g to 4.17ml/g with pupuru produced from olekanga having the highest value of 4.17ml/g and that which was produced from odongbo having the least value of 3.07ml/g. Water holding property is a term commonly used to describe the ability of a matrix of molecules, usually macromolecules, to entrap large amounts of water in a manner such that exudation is prevented [32]. Olaleye [17] reported that the difference in water absorption capacity might be due to various factors which includes the particle size, amylose/amylopectin ratio and molecular structure. Also, Akalu *et al.*, [33] reported that the larger the granular size the greater the water absorption capacity, while the higher the amylose level the lower the water binding capacity of the starches. The water absorption capacity measures the extent of water retention in the cassava products and this will affects the ability of the cassava products to form paste.

Sensory Evaluation of gari and pupuru produced from different cassava varieties

Table-5 shows the result of sensory attribute of gari and pupuru produced from different varieties of cassava. Gari samples produced from *Oko iyawo* cassava variety scored highest in all the sensory parameters tested that makes the gari the most accepted while gari produced from IITA cassava variety was least accepted. Pupuru samples from Odongbo cassava variety scored highest in terms of aroma, flavour and overall acceptability whereas *pupuru* produced from IITA cassava variety was least accepted.

Table-5: Sensory Evaluation of gari and pupuru produced from different cassava varieties

Samples	Appearance	Taste	Aroma	Flavor	Texture	Overall Acceptability
Gari						
Odongbo	7.31±1.54 [a]	7.50±0.89 [a]	7.06±1.69 [a]	7.06±1.12[ab]	7.37±1.26 [a]	7.37±1.09 [a]
IITA	5.81±1.60 [a]	6.06±1.98 [a]	5.94±2.17 [a]	5.81±2.10[a]	5.87±1.41 [a]	6.12±190 [a]
Olekanga	6.06±1.84 [a]	6.25±1.13 [a]	6.56±1.31 [a]	6.62±1.20[ab]	6.37±1.54 [a]	6.19±1.50 [a]
Oko iyawo	7.37±1.40 [a]	7.25±1.29 [a]	7.25±1.39 [a]	7.50±0.97 [b]	7.50±1.59 [a]	7.62±1.26 [a]
Pupuru						
IITA	6.12±1.54 [a]	5.94±1.53 [a]	6.37±1.26 [a]	6.31±1.49 [ab]	6.00±1.32 [a]	6.00±1.41 [a]
Oko iyawo	7.06±1.61 [a]	6.25±1.61 [a]	6.50±1.21 [a]	6.37±1.59 [ab]	6.62±1.50 [a]	6.25±1.48 [a]
Odongbo	6.75±1.53 [a]	6.00±2.22 [a]	6.81±1.60 [a]	6.62±1.59 [ab]	6.50±1.46 [a]	6.63±1.75 [a]
Olekanga	6.25±1.88 [a]	6.00±2.22 [a]	6.37±1.78 [a]	6.31±1.40 [ab]	6.81±1.97 [a]	6.56±1.79[a]

Values are means of fifteen determinations.
Means with the same superscript along the same column are not significantly different ($p<0.05$).

CONCLUSION

This work has been able reveal differences in quality of cassava products as affected by varieties of cassava. This is one of the constraints in the commercialization of local fermented cassava products as the quality of the products vary from one processor to the other and even from one processing batch to the other by the processor. This is due to the differences in methods of processing from one processor to the other, the age and the variety of the cassava root used by different processors.

REFERENCES

1. Fao, I., & Isric, I. (2010). JRC. 2009. *Harmonized world soil database (version 1.1). Food and Agriculture Organization, Rome, Italy and International Institute for Applied Systems Analysis, Laxenburg, Austria*.
2. Ene, L. S. O. (1992). Prospects for Processing and Utilization of Root and Tuber Crops. In National Root Crops Promotion of Root Crop. Based Industries. 7-11.
3. FAO. (2002). The State of Food Insecurity in the World 2002. www.Fao.org/docrep/005/y7352e/y7352e00.HTM
4. Ravindra, V., Kornegay, E. T., & Rajaguru, K. S. B. (1988). Utilization of whole cassava plant as swine feed. 13 in world Review of Animal production. 111
5. Gómez, G., & Valdivieso, M. (1985). Cassava foliage: chemical composition, cyanide content and effect of drying on cyanide elimination. *Journal of the Science of Food and Agriculture*, *36*(6), 433-441.
6. Shittu, T. A., Oyewole, O. B., Olawuyi, O., & Daramola, O. (2003). Processing technology of pupuru: a survey of practices and production quality in the south west of nigeria. *ASSET: An International Journal (Series B)}*, *2*(2), 17-27.
7. Aboaba, O. O., Nwachukwu, S. U., & Opesanwo, N. A. (1998). Microorganisms Associated with cassava fermentation for pupuru production. *Journal food Agric*, 2(1): 39_41.
8. Opeke, L. K., Laogun, E. A., Onayemi, O. O., Adetiloye, P. O., & Williams, T. O. (1986). The Place of Cassava in Household Food Security and Nutrition: A Rapid Case Study of Owo Local Government Area, Ondo State, Nigeria. *A Report on the Existing Storage and Processing Technology in the Southern Nigeria. UNICEF/IITA*, 75-87.
9. Shittu, T. A., Lasekan, O. O., Sanni, L. O., & Oladosu, M. O. (2001). The effect of drying methods on the Functional and sensory characteristics of Pukuru a fermented cassava product. *ASSET: An International Journal (Series A)}*, *1*(2), 9-16.
10. Igbeka, J. C., Jory, M., & Griffon, D. (1992). Selective mechanization for cassava processing. *Agricultural Mechanization in Asia, Africa and Latin America*, *23*(1), 45-50.
11. AOAC (2005). Official methods of analysis, association of official analytical chemists.17th ed. Washington D.C.
12. Owuamanam, C. I., Ogueke, C. C., Achinewhu, S. C., & Barimalaa, I. S. (2011). Quality characteristics of gari as affected by preferment liquor, temperature and duration of fermentation. *Am. J. Food Technol*, *6*(5), 374-384.
13. Nwanekezi, E. C., Ohagi, N. C., & OC, A. A. (2001). Nutritional and organoleptic quality of infant food formulations made from natural and solid state fermented tubers (cassava, sprouted and unsprouted yam)-soybean flours blend. Nig. *Food j*, *19*, 55-62.
14. Sanni, L. O., Babajide, J. M., & Ojerinde, M. W. (2007). Effect of Chemical Pretreatments on the Physico-Chemical and Sensory Attributes of Sweet

Potato-Gari. *ASSET: An International Journal (Series B)}*, *6*(1), 41-49.
15. Irtwange, S. V., & Achimba, O. (2009). Effect of the duration of fermentation on the quality of gari. *Current Research Journal of Biological Sciences*, *1*(3), 150-154.
16. Odetokun, S. M., AIYESAMNI, A., & Esuoso, K. O. (1998). Enhancement of the nutritive value of pupuru, a fermented cassava product. *Rivista Italiana delle Sostanze Grasse*, *75*(3), 155-158.
17. Olaleye, O. O. (2013). Effects of storage on quality attributes of cassava roots products: M.Tech thesis, Ladoke Akintola University of Technology, Ogbomoso.
18. Fasuyi, A. O., & Aletor, V. A. (2005). Varietal composition and functional properties of cassava (Manihot esculenta, Crantz) leaf meal and leaf protein concentrates. *Pakistan Journal of Nutrition*, *4*(1), 43-49.
19. Komolafe, E. A., & Arawande, J. O. (2010). Evaluation of the quantity and quality of gari produced from three cultivars of cassava. *Journal of Research in National Development*, *20*, 2027-2039.
20. Obatolu, V. A., & Osho, S. M. (1992). Nutritional Evaluation of staple foods in Lagos State (New project). *Second year: Technical report. April 1, 1991 to April 30, 1992. IDRC/IITA Soybean Utilization project phase*, 194-207.
21. Oluwamukomi, M. O., & Adeyemi, I. A. (2013). Physicochemical Characteristics of "Gari" Semolina Enriched with Different Types of Soy-melon Supplements.
22. Apea-Bah, F. B., Oduro, I., Ellis, W. O., & Safo-Kantanka, O. (2009). Principal components analysis and age at harvest effect on quality of gari from four elite cassava varieties in Ghana. *African Journal of Biotechnology*, *8*(9).
23. Akingbala, J. O., Oyewole, O. B., Uzo-Peters, P. I., Karim, R. O., & Baccus-Taylor, G. S. (2005). Evaluating stored cassava quality in gari production. *Journal of Food, Agriculture & Environment*, *3*(1), 75-80.
24. IITA. (1989). Cassava processing and utilization. International Institute for Tropical Agriculture, Ibadan, 28: 16-18.
25. CCDN. (2006). Cassava Cyanide Diseases Network (CCDN): http://www/anu/edu/au/BoZo/CCDN/two.html.
26. Enidiok, S. E., Attah, L. E., & Otuechere, C. A. (2008). Evaluation of moisture, total cyanide and fiber contents of garri produced from cassava (Manihot utilissima) varieties obtained from Awassa in Southern Ethiopia. *Pakistan Journal of Nutrition*, *7*(5), 625-629.
27. Odoemelam, S. A. (2005). Studies on residual hydrocyanic acid (HCN) in garri flour made from cassava (Manihot spp.). *Pakistan Journal of Nutrition4*, *6*, 376-378.
28. O'Brien, G. M., Mbome, L., Taylor, A. J., & Poulter, N. H. (1992). Variations in cyanogen content of cassava during village processing in Cameroon. *Food Chemistry*, *44*(2), 131-136.
29. Adindu, M. N., & Aprioku, A. B. I. (2006). Cyanogenic content of" Gari" from some processing centres in Rivers State, Nigeria. *Nigerian Food Journal*, *24*(1), 135-138.
30. Ukpabi, U. J., & Ndimele, C. (1990). Evaluation of the quality of gari produced in Imo State. *Nigerian Food Journal*, *8*, 105-109.
31. Udensi, E. A., & OKAKLA, J. (2000). Predicting the effect of particle size profile, blanching and drying temperature on the dispersability of yam flour. *Global Journal of Pure and Applied Sciences*, *6*(4), 589-592.
32. Chen, M. J., & Lin, C. W. (2002). Factors Affecting the Water-Holding Capacity of Fibrinogen/Plasma Protein Gels Optimized by Response Surface Methodology. *Journal of food science*, *67*(7), 2579-2582.
33. Akalu, G., Tufvesson, F., Jönsson, C., & Nai, B. M. (1998). Physico-chemical characteristics and functional properties of starch and dietary fibre in grass pea seeds. *Starch‐Stärke*, *50*(9), 374-382.