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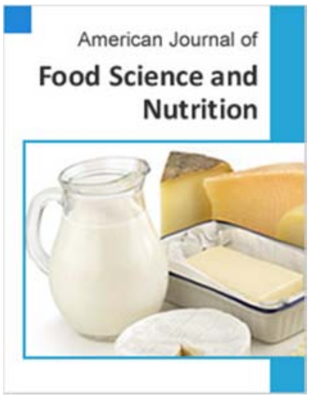

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Quality Assessment of Cassava *Gari* Produced in Some Selected Local Governments of Ekiti State, Nigeria

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Abstract
This study assessed the quality of *gari* produced in major *gari* processing areas in Ekiti State as a means of measuring its conformity with some recommended standards and major quality attributes demanded for in *gari.* Samples of *gari* produced in seven processing areas spread across the three senatorial districts of Ekiti State were collected at the point of production and analyzed for chemical, pasting and functional properties. The range of moisture, ash, crude fibre and protein contents of all the samples were 8.48% - 9.86%, 1.85% - 2.05%, 1.77% - 1.98% and 1.96% - 2.88% respectively. The hydrogen cyanide contents of the samples compared favourably with the recommended standard of 20mg/kg by the Standard Organization of Nigeria (SON). *Gari* sample produced in Ikere had the highest peak viscosity of 324.25RVU (at a pasting temperature of 83.05°C in 5.42minutes) while Ado-Ekiti sample had the lowest peak viscosity of 133.50RVU (at a pasting temperature of 82.05°C in 6.00 minutes). The final viscosity, breakdown viscosity and setback viscosity of the samples were in the range of 145.25 RVU - 290.58 RVU, 48.42 RVU - 162.97 RVU and 60.17 RVU - 98.83 RVU respectively. The range of swelling index, water absorption capacity, bulk density, titratable acidity and pH of the samples were 2.50 - 3.40, 5.00ml/g - 6.00 ml/g, 0.58g/ml - 0.67 g/ml, 0.004% - 0.016% and 3.90 - 4.60 respectively. Generally, the quality of *gari* samples from the selected areas was good and many of the samples met the recommended standard.

1. Introduction

Cassava (*Manihot esculenta crantz*) is a native of South America but was introduced to West Africa in the late 16th century where it is now an important staple in Nigeria, Ghana and some other African Countries [1]. Cassava plays a very important role in Nigeria's food security since majority of Nigerian eat cassava products at least once a day. Cassava roots is highly perishable and therefore cannot be stored in the fresh form for a longer period [2]; also presence of two cyanogenic glucosides, *linamarin* and *lotausralin* which on hydrolysis by enzyme release toxic hydrogen cyanide [3], is another major problem in the utilization and consumption of cassava. As a result of these limiting factors, cassava is usually processed into many food products including the traditional foods like *gari, fufu, tapioca.*

Gari is creamy-white partially gelatinized roasted free flowing granular flour made from cassava roots [4]. Typical processing steps involved in the production of *gari* include peeling of cassava roots, washing, grating, fermentation, dewatering, sieving and roasting. The roasting process which usually dextrinizes the starch and dries the granules is called *garification*. *Gari* is consumed in almost all parts of Nigeria and in many West African countries like Ghana, Republic of Benin, Togo [5]. It is a good source of energy and fibre; its cheapness, ease of storage and preparation for consumption have combined to make it an important food item in Nigeria. Recently biofortified cassava varieties that contain significant levels of provitamin A carotenoids have been developed and used for the production of *gari* [6]. *Gari* is commonly consumed either by soaking in cold water with sugar, roasted groundnut or stirred in hot water to make stiff dough (*eba*) which can then be eaten with sauces or stews.

Several factors such as variety and age of cassava at harvesting, processing methods and storage methods affect the quality of *gari*. Many gari producers because of high demand usually reduce the fermentation period and other processing parameters in order to save time and make good returns. This short cut practices may leave high residual cyanogenic glucosides and cyanide in the product which can cause consumers to suffer from acute toxicity and some physiological disorders such as induced paralytic disease [7]. Likewise this will lead to variation in the quality of *gari* from batch to batch with the attendant negative effect on the reliability of the quality of the product by consumers and the export potential of the product. There are many gari processing areas in Ekiti state scattered in all the local government areas from where the urban consumers of gari get their stock. It is a usual observation to see gari of different qualities processed in several processing areas being offered for sale in the popular King's market in Ado-Ekiti, the capital city of Ekiti state. This seemingly lack of standardization in the processing of cassava to gari and the fact that there is little information on the quality characteristics of gari produced in these processing areas underscore the need to evaluate the quality of *gari,* a common convenient food in Ekiti State. Market expansion for *gari* to some extent depends largely on the degree to which the quality of the processed *gari* can be sustained and improved upon [8]. This paper examined the chemical, pasting and functional qualities of *gari* produced in major *gari* processing areas in Ekiti State.

2. Materials and Methods

2.1. Preliminary Survey

In order to have good representative samples of *gari* produced in Ekiti State, a preliminary survey was carried out to identify major *gari* processing areas among sellers and consumers of *gari* in Ekiti State. One hundred sellers and consumers of gari were requested to identify major gari processing areas in each local government of the State. Two gari processing areas in different Local Government that has the highest number of occurrence were selected per each senatorial district of Ekiti State. Ado Ekiti being the capital city of the state was also selected as the seventh processing area (Table 1).

2.2. Sample Collection

Seven *Gari* samples were collected at the processing site in each of the seven identified processing areas. The collected samples were stored in airtight well labeled polythene bags at ambient temperature.

2.3. Chemical Analysis

Protein, fat, fibre, ash, moisture and pH of the various *gari* samples were determined according to standard methods described by AOAC [9], carbohydrate was determined by difference, while the residual cyanide content of the *gari* samples was determined using the method of Essier *et. al*. [10]. Total titratable acidity (TTA) was determined in accordance to the method of FAO [11] as described by Owuamanam *et. al.* [12]. Five grams of the sample was mixed with 100ml of distilled water and allowed to stand for 30mins. The mixture was filtered through filter paper, 25ml of the filtrate was titrated with 0.1M sodium hydroxide using phenolphthalein as indicator to a colourless end point and the percent titratable acidity (as lactic acid) was calculated using formula (1)

$$\text{TTA}\ (\%) = 0.01X \tag{1}$$

Where X = Titre value

2.4. Pasting Analysis

The pasting properties were determined using Rapid Visco Analyser (RVA) (Model Rva-3D). Three grams of the sample was turned to slurry by mixing with 25ml of water; this was then transferred into RVA canister and placed inside the RVA machine. The 12 minutes profile was used with sample heated from 50°C to 95°C and then cooled back to 50°C.

2.5. Analysis of Functional Properties

2.5.1. Swelling Index

Swelling index was determined according to the method described by Onwuka [13] with slight modification. 50ml measuring cylinder was filled with the *gari* sample up to 10ml mark; distilled water was then added up to 50ml mark. The content of the tightly covered measuring cylinder was mixed by inverting it several times for 2 minutes. The cylinder was allowed to stand for 5 minutes after which the volume occupied by the sample was noted. Swelling index was calculated using formula (2).

$$\text{Swelling index} = \frac{\text{volume of sample in water}}{\text{initial volume of sample}} \tag{2}$$

2.5.2. Water Absorption Capacity

The method described by Sathe *et. al*. [14] was adopted for the determination of the water absorption capacity of the samples. One gram of each sample was weighed into a centrifuge tube, 10 ml of distilled water was added and the suspension was stirred properly. The suspension was then allowed to stand for 30 minutes at room temperature after which it was centrifuged at 5,000rpm for 30 minutes, after centrifugation the volume of the supernatant was measured and the result was expressed as volume (ml) of water absorbed per gram of the sample.

2.5.3. Bulk Density

10 ml measuring cylinder was weighed and then gently filled with the sample; the cylinder was tapped repeatedly for about 5 minutes until there was no further reduction in the sample level after filling up to the 10 ml mark. The weight of the cylinder with the sample was taken and bulk density was calculated as weight per unit volume of the sample.

2.6. Statistical Analysis

The difference in the experimental data was tested for statistical significance $P \leq 0.05$ by Statistical Analysis of Variance (ANOVA) using SPSS 17.0 software package (Statistical Package for Social Scientist, Michigan, USA).

3. Results and Discussion

3.1. Chemical Properties

The results of the chemical composition of the various *gari* samples (Table 2) show that the moisture content was in the range of 8.48% to 9.86%. There was significant difference in the moisture contents of the samples and this may be due to the method of *garification*; sample produced at Oke-Imesi had the lowest moisture content while *gari* produced at Isan had the highest moisture content. The moisture contents of all the *gari* samples fall below the stipulated standard of the revised *gari* regulation of 10% [15] and the recommended safe level (12% - 13%) for storage of cassava flour [16]. It can be deduced that *gari* produced in Ekiti state with moisture contents generally below 10% has good storage potential and therefore can be included in the National Strategic Food Reserve Programme. Ukpabi and Ndimele [17] had reported that *gari* samples with moisture content of 13% to 16% can be successively stored for up to 7months without mould infestation.

The protein content of *gari* samples was in the range of 1.96% to 2.88%, this range is comparable to the range of protein content (1.57% - 2.24%) reported for *gari* produced from fresh cassava roots and dried cassava chips [18]. There was significant difference in the protein content of virtually all the samples and this may be as a result of the difference in the chemical composition of varieties of cassava used to produce the gari samples. The protein contents of all the samples in this study were higher than 0.90% reported for raw cassava roots by Oluwole *et. al*. [2]; this increase may be as a result of the biomass involved in the fermentation and also due to relative reduction in moisture content (concentration effect). It is generally known that there will be increase in the constituents of any biomaterial once moisture has been reduced. The fat content of *gari* sample produced at Ikere was the highest while that of the sample produced at Oke-Imesi was the lowest; the variation in the fat content may be as a result of application of different quantity of palm oil during *garification*. It is a common practice among some traditional *gari* producers to add palm oil to the product during *garification* in order to enhance the colour of the product and based on this, *gari* is sometimes classified as white or yellow.

There were variations in the ash and crude fibre contents of the various *gari* samples; however, this variation was not statistically significant. The values of ash contents reported for *gari* produced in Ekiti state as indicated in this study were higher than 10g/kg (1.0%) reported for *gari* by Akingbala *et. al*. [19]. The ash contents of all the samples were lower than 2.75% maximum level permitted for *gari* [20]. The range of crude fibre contents (1.77% - 1.98%) falls within the regulatory maximum standard of 2.0% [15, 20]. The less fibrous a *gari* sample is, the better its quality [21], therefore all *gari* samples in this study can be adjudged to be of good quality because of their low fibre content.

There was significant difference in the hydrogen cyanide contents of all the *gari* samples with *gari* produced at Isan having the highest of 21.50 mg/kg and *gari* produced at Ado-Ekiti having the lowest of 15.50 mg/kg. Sanni *et. al*. [4] reported similar variation in the cyanide contents of *gari* samples from major processing centers and markets in Lagos State of Nigeria. The variation in the cyanide contents can be attributed to the use of high/low cyanogenic glucosides containing cassava varieties, long or short fermentation period and adequate/inadequate *garification*. Aworh [1] reported that generally, cassava contains 10 – 500 mg HCN/kg of root depending on the variety and some unusual varieties may contain higher level exceeding 1000 mg HCN/kg; and that processing of cassava roots into gari is the most effective means of reducing cyanide content to a safe level. It is also known that traditional *gari* processor employ different fermentation period and *garification* method, and the rate of decomposition of cyanogens to hydrogen cyanide during fermentation and subsequent elimination of the cyanide during *garification* are influenced by the length of fermentation and quantity of heat supply during *garification* respectively. Arinola [22] had reported that longer *garification* duration helps to reduce the residual cyanide content of *gari*. The cyanide contents of all *gari* samples reported in this study were higher than 13.50 mg/kg reported by Akingbala *et. al*. [19] but did not significantly exceed the recommended standard of 20 mg/kg by the Standard Organisation of Nigeria (SON) and International Institute of Tropical Agriculture (IITA) as reported by Sanni *et. al*. [15]. All the *gari* samples investigated in this study revealed a slightly acidic nature; the values of the titratable acidity of all the samples were below the maximum recommended standard of 1% [15, 20] however the variation in the acidity values may be due to different fermentation period employed by the processing areas. The pH values compare favourably with a range of 3.76 – 4.88 reported by Sanni *et. al.* [4] for *gari* produced in Lagos State.

Table 1. *Selected Gari Processing Areas in Ekiti State.*

S/N	Processing Area	Local Government	Senatorial District
1	Emure	Emure	Ekiti South
2	Ikere	Ikere	
3	Isan	Oye	Ekiti North
4	Ikole	Ikole	
5	Ara	Ijero	
6	Oke-Imesi	Ekiti West	Ekiti Central
7	Ado-Ekiti	Ado-Ekiti	

Table 2. *Chemical Properties of Gari Produced in Different Processing Areas of Ekiti State.*

Samples	Moisture %	Protein %	Fat %	Ash %	Crude Fibre%	Carbo-hydrate%	HCN mg/kg	pH	%TTA
Emure	9.18 ± 0.15^{b}	2.75 ± 0.05^{de}	1.08 ± 0.03^{c}	1.87 ± 0.20^{a}	1.88 ± 0.11^{a}	83.24 ± 1.20^{a}	20.70 ± 0.03^{d}	3.90 ± 0.04^{a}	0.015 ± 0.001^{d}
Ikere	9.68 ± 0.30^{cd}	2.28 ± 0.10^{b}	1.58 ± 0.07^{f}	1.95 ± 0.15^{a}	1.84 ± 0.10^{a}	82.67 ± 0.81^{a}	17.50 ± 0.06^{b}	4.10 ± 0.02^{b}	0.010 ± 0.002^{c}
Isan	9.86 ± 0.20^{d}	2.25 ± 0.07^{b}	1.38 ± 0.10^{e}	2.05 ± 0.05^{a}	1.86 ± 0.20^{a}	82.60 ± 1.10^{a}	21.50 ± 0.07^{d}	3.90 ± 0.04^{a}	0.016 ± 0.001^{d}
Ikole	9.33 ± 0.10^{bc}	2.88 ± 0.12^{e}	0.86 ± 0.02^{ab}	1.97 ± 0.07^{a}	1.77 ± 0.15^{a}	83.19 ± 0.75^{a}	16.90 ± 0.05^{b}	4.20 ± 0.05^{c}	0.006 ± 0.001^{ab}
Ara	9.63 ± 0.20^{cd}	2.48 ± 0.10^{c}	1.23 ± 0.10^{d}	1.93 ± 0.10^{a}	1.98 ± 0.06^{a}	82.75 ± 1.00^{a}	20.60 ± 0.04^{d}	4.30 ± 0.05^{d}	0.006 ± 0.001^{ab}
Oke- Imesi	8.48 ± 0.12^{a}	2.63 ± 0.20^{cd}	0.75 ± 0.05^{a}	1.96 ± 0.05^{a}	1.78 ± 0.10^{a}	84.40 ± 1.30^{a}	18.60 ± 0.09^{c}	4.60 ± 0.02^{e}	0.004 ± 0.001^{a}
Ado-Ekiti	9.45 ± 0.20^{bc}	1.96 ± 0.06^{a}	0.97 ± 0.03^{bc}	1.85 ± 0.15^{a}	1.93 ± 0.11^{a}	83.84 ± 0.97^{a}	15.50 ± 0.02^{a}	4.10 ± 0.01^{b}	0.008 ± 0.001^{bc}

Means of triplicate determination ± standard deviation
Values in the same column with different superscript are significantly different (P≤0.05)

3.2. Pasting Profile

The pasting profile of different *gari* samples produced in Ekiti State which reveals how *gari* will behaves when it is stirred in hot water to make a stiff paste popularly called *eba* in the southwestern part of Nigeria is presented in Table 3. The pasting temperature of all the *gari* samples fall below 100°C, the boiling point of water, but higher than values reported for some other cassava products [23, 24]. There was significant difference in the pasting temperature of all the samples with *gari* produced at Isan having the highest (83.66°C) while gari produced at Ado-Ekiti had the lowest pasting temperature (82.05°C). The range of the pasting temperature of *gari* samples in this study was higher than that of gari samples (63.40°C – 64.65°C) sourced from major gari processing areas and markets in Lagos State, Nigeria [4]. It has been reported that elevation in the gelatinization temperature of cassava flour might be attributed to high fibre content [25]. Pasting temperature is an index of minimum energy require to initiate rapid water ingression, swelling and eventual gelatinization of starch granules. The combination of pasting temperature and time would determine the amount of energy required to cook the sample. The peak time is the time taken to attain peak viscosity, it is also a measure of the cooking time [26], the shorter the peak time the higher the ease of cooking and the lesser the energy required for cooking. *Gari* produced at Ara had the lowest peak time of 5.22 minutes, with a relatively low pasting temperature, the sample will require lesser energy to attain peak viscosity and complete the cooking process when compared with other samples.

The peak viscosities of the samples were in the range of 133. 50 RVU to 324.25 RVU with *gari* samples from Ado-Ekiti and Ikere having the lowest and highest peak viscosity respectively. This difference in peak viscosity of the samples may be due to varying degree of *garification* as there are no specific or standard processing conditions of time and temperature. Peak viscosity of the samples, which reflects the maximum viscosity developed during cooking and gives an indication of the viscous load to be encountered during mixing, are lower than values reported for *lafun, and fufu* by Shittu and Adedokun, [24]. This difference may be attributed to the fact that *gari* is a partially gelatinized cassava products. There was significant difference in the final viscosity of the samples. The final viscosity indicates the ability of the starch-based food to form a viscous paste or gel after cooking and cooling [23] and it is useful in predicting and defining the final textural quality of starchy foods. Therefore *gari* from Oke-Imesi and Ikere with the highest final viscosity will form sticky dough (*eba*) which may be preferred by some consumers.

The ability of a sample to withstand reduction in viscosity during heating with the application of mechanical shear stress is measured by breakdown viscosity; the higher the breakdown viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking [26]. There was significant difference in the breakdown viscosity of the samples, sample from Ado-Ekiti and Oke-Imesi had relatively low breakdown viscosity of 48.42 RVU and 75.00 RVU respectively, this implies that these samples were more resistant to heat and shear stress force during heating and therefore would have high paste stability. The phase of the pasting curve after cooling of the sample to 50°C is known as setback region and it show the tendency of starch to re-associate and retrograde; lower setback during the cooling of the paste indicates greater resistance to retrogradation [27]. *Gari* sample produced at Oke-Imesi had the highest setback value while sample produced at Ado-Ekiti had the lowest setback value, this suggests that dough (*eba*) prepared from *gari* produced at Ado-Ekiti is most likely to exhibit low retrogradation tendency.

Table 3. Pasting Profile of Gari Produced in Different Processing Areas of Ekiti State.

Samples	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (minute)	Pasting Temperature (^{o}C)
Emure	322.30±0.04^{f}	159.33±0.05^{d}	162.97±0.03^{g}	235.92±0.06^{d}	76.59±0.05^{e}	5.33±0.02^{c}	82.56±0.04^{abc}
Ikere	324.25±0.0 ^{g}	200.00±0.02^{g}	124.25±0.05^{c}	290.33±0.03^{f}	90.33±0.01^{f}	5.42±0.02^{d}	83.05±1.00^{cd}
Isan	306.42±0.0 ^{e}	163.42±0.02^{e}	143.00±0.00^{e}	236.00±0.00^{e}	72.58±0.02^{d}	5.88±0.01^{f}	83.66±0.05^{d}
Ikole	300.42±0.03^{d}	151.75±0.05^{c}	148.67±0.03^{f}	220.00±0.02^{c}	68.25±0.05^{b}	5.65±0.02^{e}	82.79±0.04^{bc}
Ara	289.08±0.02^{c}	147.58±0.05^{b}	141.50±0.02^{d}	217.17±0.05^{b}	69.59±0.01^{c}	5.22±0.01^{a}	82.18±0.03^{ab}
Oke- Imesi	266.75±0.04^{b}	191.75±0.02^{f}	75.00±0.04^{b}	290.58±0.04^{g}	98.83±0.02^{g}	5.29±0.02^{b}	82.70±0.00^{abc}
Ado-Ekiti	133.50±0.01^{a}	85.08±0.02^{a}	48.42±0.03^{a}	145.25±0.10^{a}	60.17±0.03^{a}	6.00±0.04^{g}	82.05±0.05a

Means of triplicate determination ± standard deviation
Values in the same column with different superscript are significantly different (P≤0.05)

3.3. Functional Properties

The functional properties of the various *gari* samples are presented in Table 4. The swelling index which depicts the ability of *gari* to swell in water was in the range of 2.50 to 3.40, *gari* samples produced at Emure and Isan had the lowest swelling index while sample produced at Ado-Ekiti had the highest swelling. This difference in swelling index may be attributed to the *garification* duration of the samples [22]. The range of swelling index reported in this work was comparable to 2.54 to 3.45 reported for *gari* by Agunbiade and Adanlawo [7]. Almazan *et. al*. [21] had reported that good quality *gari* should swell to at least 3 times its volume when soaked in water. Swelling indicates the degree of exposure of the internal structures of the starch granules to action of water [28]. There was significant difference in the water absorption capacity of the *gari* samples, the values reported in this work for *gari* samples were higher than 1.05 ml/g reported for *gari* by Owuamanam *et. al*. [12]. This difference may be due to difference in the variety of cassava used and variation in the degree of *garification*. The bulk density was in the range of 0.58 g/ml to 0. 67 g/ml; generally the lower the bulk density the higher the floatation of gari sample on top of water, this is undesirable as the gari may not soak well in water and may therefore be rejected by consumers. The range of bulk density of *gari* samples reported in this work was comparable to that (0.54g/ml – 0.61g/ml) reported by Sanni *et al*. [4] for *gari* samples produced in Lagos State. The high gram per volume of flour material is important in relation to its packaging. High bulk density is desirable in that it offers greater packaging advantage as greater quantity may be packaged within a constant volume [29].

Table 4. Functional Properties of Gari Produced in Different Processing Areas of Ekiti State.

Samples	Swelling Index	Water Absorption Capacity (ml/g)	Bulk Density(g/ml)
Emure	2.50±0.02^{a}	5.00±0.20^{a}	0.58±0.02^{a}
Ikere	2.60±0.04^{ab}	5.00±0.00^{a}	0.59±0.01^{a}
Isan	2.50±0.04^{a}	5.00±0.20^{a}	0.62±0.03^{a}
Ikole	3.10±0.10^{c}	6.00±0.40^{c}	0.62±0.01^{a}
Ara	2.70±0.06^{b}	5.60±0.20^{b}	0.60±0.04^{a}
Oke-Imesi	2.70±0.10^{b}	5.20±0.00^{a}	0.59±0.02^{a}
Ado-Ekiti	3.40±0.06^{d}	5.40±0.20^{ab}	0.67±0.02^{b}

Means of triplicate determination ± standard deviation
Values in the same column with different superscript are significantly different (P≤0.05)

4. Conclusion

Gari produced in these seven *gari* processing areas of Ekiti State had good swelling index, water absorption capacity and pasting profiles that suit the two major uses of *gari* in Nigeria. The moisture contents which were relatively low indicate better storage potential; crude fibre and the cyanide contents compared favourably with the recommended standard.

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