Some quality characteristics of Gari as influenced by roasting methods

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Abstract: In this study, the effect of mechanized roasting on some properties and proximate composition of gari was investigated. Pulverized and sifted cassava mash was roasted by conductive rotary drying and traditional manual method. Products from the two methods were compared using the students' t-test and the results showed that bulk density and coefficient of uniformity of mechanically roasted gari of 469.89 kg/m3 and 2.89, respectively, were not significantly different (p>0.05) from those of manually roasted gari of 472.74 kg/m3 and 2.53, respectively. The swelling indices of the two products were 3.29 and 3.69, respectively, which were significantly different (p < 0.05) and greater than the recommended swelling index of 3.0 required for high quality gari. The proximate composition of gari obtained from the two roasting methods were not significantly different (p>0.05) and in conformity with quality specifications recommended by Standard Organization of Nigeria (SON). Sensory evaluation showed that consumers preferred the colour, taste and texture of the mechanically roasted gari. The quality characteristics of gari produced by conductive rotary drying were better than those of gari produced by manual method. This provides a strong basis for industrializing gari production at a commercial scale.

Keywords: conductive rotary drying, gari, properties, roasting methods

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1 Introduction

Gari is a gelatinized, roasted, granular product prepared from peeled, grated and fermented cassava (*Manihot esculenta* Crantz.) roots (Asiedu, 1989). Largely consumed in Nigeria and some other parts of Africa, *gari* is perhaps the most widely consumed cassava product. It is often whitish or yellowish in colour and accepted in various particle sizes by different populations depending on intended use either as food snack or as raw material for other food preparations. Nigeria alone produces over 40 million metric tons of cassava annually and over 70% of total cassava produced in West Africa is processed into *gari* (Saliou, 2002; Babatunde, 2012). This makes *gari* the most popular and most widely consumed product from cassava (Oluwole et al., 2004; FAO, 2000). In Nigeria and many African countries *gari* is consumed in various forms either as snack or a full meal (Irtwange and Achimba, 2009).

Gari processing involves peeling and milling or grating of cassava roots. The cassava mash is tightly packed in heissian sacks and left for 1-3 days to ferment. Fermentation affects the pH and is responsible for the characteristic flavour of *gari* (Kemdirin et al., 1995; Ikujenlola and Opawale, 2007). The fermented cassava mash is pressed to remove the free water. Sometimes fermentation and pressing take place simultaneously, but pressing reduces the moisture content of the cassava mash to 40% - 50% wet basis depending on the efficiency of the press used (Kolawole et al., 2011). The product of pressing is a caked mass which is manually pulverized and sifted on a hand-woven raffia screen to remove the fibre content and in some cases un-milled cassava root (Sanni et al., 2008). Finally, the granular cassava meal is roasted on a pre-heated metallic tray at a temperature range of 193 ^oC - 200 ^oC and stirred continuously until a

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gelatinized and dried meal known as *gari* is obtained - a process otherwise called 'garification'. Owuamanam et al., 2010 had earlier found that garification further detoxifies the cassava meal and reduces its cyanide content to consumable level of about 10 ppm. The characteristic colour of *gari* is white or cream depending on the intensity of heat during roasting. Udofia et al., 2010 reported on yellow *gari* which is usually achieved by the addition of palm oil during fermentation or roasting. It was established that this also reduces the toxicity of the product.

The functional and sensory properties of *gari* have been found to vary widely between communities and processors and the low quality of some *gari* products has been attributed to poor handling and processing methods (Irtwange and Achimba, 2009; Owuamanam et al., 2010; Udofia et al., 2010). Cultivar and age of the cassava have also been found to affect the proximate composition of *gari* (Apea-Bah et al., 2009). A survey of cassava processors in South-Western Nigeria, found that *gari* production enterprise was generally dominated by women and children and over 95% of the processors used manual methods to process the cassava (Ajibola et al., 1998). Body aches (due to sitting posture during roasting), exposure of the food to contamination, limited production capacity and low quality of *gari* are problems associated with manual *gari* roasting. These notwithstanding, the demand for *gari* is increasing worldwide and 'technopreneurs' are now interested in deploying modern cassava processing equipment to increase production and raise the quality of *gari* to export standard (SON, 2004). Research efforts have gone into the design and fabrication of mechanical roasters for *gari* production with little commercial success (Odigboh, 1984; Davies et al., 2008; Samuel et al., 2010). The Brazilian model of '*gari* fryer' has been adopted by a few entrepreneurs in Nigeria. The Brazilian mechanical roaster (NijiLukas, 1994) simulates the traditional open-tray roasting method where stirring of the *gari* is achieved by the rotation of metallic fingers whose central and orbiting shaft is driven by low-speed geared motor. However the *gari* is exposed to contamination from the surrounding and evacuation of the product is done manually.

A conductive rotary dryer (CRD) based on the principle of 'contact' or 'indirect' drying of cassava meal was developed for roasting *gari* (Sanni, 2014). The drum speed, drum temperature, vapour extraction rate and quantity of cassava were the parameters which influenced the performance of the dryer in roasting *gari*. The effect of the parameters on the drying rate and swelling index of *gari* was investigated and optimized and satisfactory results were obtained (Sanni et al., 2015). Unlike the Brazilian model and traditional manual method, the *gari* was completely enclosed in the rotary chamber and protected from contamination. Evacuation of *gari* was done pneumatically by cyclone and handling time was greatly reduced. Apart from moisture content and swelling index of the *gari* produced in the dryer, other quality characteristics such as sensory attributes and proximate composition of the *gari* needed to be investigated and ascertained before introducing the machine to the cassava processing industry. The investigations were carried out to compare the consumer preference for *gari* produced from the mechanical and traditional methods. The objective of this work is to investigate the effect of the mechanized roasting on some properties and proximate composition of *gari* compared to manual roasting method.

2 Materials and methods

2.1 Preparation of cassava meal

Fresh cassava tubers of the variety TMS 30572 were harvested from the Teaching and Research Farm of the Obafemi Awolowo University, Ile-Ife. The cassava tubers were washed, peeled and milled in a motorized grater. Thirty-five kg of the grated mash was collected in each of 4 heissian sacks and kept on a rack for 48 h for fermentation of the cassava mash at room temperature. The sacks were placed under a vertical screw press for 3 h until the cassava mash was dewatered to average of 45%

moisture content (wet basis). The compressed cassava cakes were pulverized and sifted into a granular meal using the hand-woven raffia screen. Three batches of 4 kg each were taken from the cassava meal and each batch was roasted manually by three different women using the traditional method of a metallic tray placed on wood fire. In traditional manual roasting with fire wood as heat source, the average roasting time and pan temperature were 35-40 min and 193°C-200°C, respectively (Sanni, 2014). Another set of three batches of 6 kg each were taken from the cassava meal and each batch was roasted in the conductive rotary dryer for 35 min. The heating elements and suction fan of the dryer were regulated to achieve 200°C drum temperature and vapour extraction rate of 0.0075 m^3/s. The dryer was allowed to cool and properly cleaned before the next experiment. The batches of *gari* produced by the manual and mechanical methods were collected in dry plastic containers and tightly covered to prevent moisture migration. The containers were labelled and samples were taken from each batch for evaluation of functional and sensory properties and proximate composition of *gari* produced. The data obtained were subjected to statistical analysis using the students' t-test.

2.2 Determination of bulk density

Bulk density was determined using the method of Sanni et al. (2008). A cylindrical container of known volume was weighed and filled with cassava meal from each of the six batches of *gari*. For each experiment, the container was tapped on a table five times after which it was weighed with its full content. The weight of *gari* in the container was determined and the bulk density of each sample was calculated using Equation (1).

$$\text{Bulk density} = {}^{\text{weight of cassava meal}}\!/_{\text{volume of can}} \quad (1)$$

2.3 Particle size analysis

The particle size distribution for each sample was determined by sieve analysis according to Serpil and Servet (2006). Two hundred grams was sieved through a standard set of sieves with mesh sizes 2.36, 1.70, 1.00, 0.50, 0.25, 0.15, 0.075, 0.053 mm and a base pan. The set of sieves (Endecotts, England) was shaken in a mechanical shaker for 15 min after which each sieve and its content was weighed and the mass fraction of *gari* retained on each sieve determined. This was used to calculate the percentage of *gari* that passed through each sieve. The percentage of particles that passed through each sieve was plotted against the sieve size and particle size distribution curve was drawn on a logarithmic graph for each sample. According to Sanni et al. (2008), the coefficient of uniformity (C_u) is a measure of how uniformly distributed the particle size is. C_u was calculated for each sample using Equation (2).

$$\text{Coefficient of uniformity} = {}^{D_{60}}\!/_{D_{10}} \quad (2)$$

where D_{60} and D_{10} are the mesh sizes through which 60% and 10% of sample placed on the sieve would pass through, respectively.

2.4 Determination of swelling index

The swelling index of *gari* samples was determined using the method of Irtwange and Achimba (2009) with slight modification. About 10 g of *gari* sample was placed in a 100 ml measuring cylinder and its initial volume of 18 ml was recorded. The cylinder was filled with distilled water at room temperature, to the 100 ml mark, corked and shaken by repeatedly turning the cylinder up-side-down for 5 min. The solution was then allowed to settle for 5 min before shaking again. The intermittent shaking and settling lasted for 20 min. After this, the final volume of the *gari* was recorded. The swelling index was calculated using Equation (3).

$$\text{Swelling index} = {}^{\text{final volume of } gari}\!/_{\text{initial volume of } gari} \quad (3)$$

2.5 Determination of colour

About 200 g was taken from each of the manually roasted *gari* samples and thoroughly mixed together in a container. The same was done for the mechanically roasted *gari* samples. The colour of each mixture of *gari* was determined using the Munsel System of Colour analysis as used by Akinwande et al. (2008). The readings obtained were used to determine the hue, value and chroma for each sample from the Munsel Tables and Charts.

2.6 Proximate analysis

The AOAC (2012) method was used to determine the proximate composition of carbohydrate, moisture, ash, crude fibre, crude protein and ether extract of *gari* samples.

2.7 Evaluation of sensory attributes

Consumers' assessment of colour, taste, texture and acceptability of the *gari* samples were evaluated on a 5-point Hedonic scale (Irtwange and Achimba, 2009; Owuamanam et al., 2010; Udofia et al., 2010). Thirty adults (15 female and 15 male) who were regular consumers of *gari* were randomly selected from Obafemi Awolowo University campus, Ile-Ife for the evaluation. Two samples of *gari* from batches roasted in the conductive rotary dryer and two samples from batches roasted by manual method were placed in four identical plastic bowls with tight covers. The bowls were coded as Sample 1, Sample 2, Sample 3, and Sample 4 respectively and placed on a tray with table spoon. A questionnaire was designed and distributed among the 30 respondents to score the four attributes for each of the samples on a Hedonic scale of 5 points: 1 = poor; 2 = fair; 3 = satisfactory; 4 = good; 5 = excellent. Each of the four dry *gari* samples was presented at different times to each of the thirty respondents to avoid bias of judgement. The responses were collated for analysis to compare the consumer preferences of the *gari* produced by the mechanical and manual methods.

3 Results and discussion

Some properties of the *gari* products from the conductive rotary dryer and traditional roasting method are presented in Table 1 and statistical analysis showed that the difference in the bulk density and coefficient of uniformity of the two products were not significant ($p > 0.05$). This implies that the two methods produced *gari* products with similar particle size distribution. The swelling index of manually roasted *gari* was higher than that of mechanically roasted *gari*; this difference was significant at $p < 0.05$. Values for swelling capacity of *gari* produced from the roasting methods considered in this study were however, higher than the recommended minimum swelling index of 3.0 for good quality *gari* (Ajibola et al., 1987; Apea-Bah et al., 2009). Using the Munsel System of colour code, the manually roasted *gari* had a hue, value and chroma of 2.8Y, 8.55 and 2.43, respectively meaning that its color was 28% yellow and light/saturated. The mechanically roasted *gari* had a hue, value and chroma of 5.0 GY, 8.99 and 10.5 respectively meaning that its color was 50 % green-yellow and light/saturated. This implies that both products were creamy in colour but the mechanically roasted *gari* was lighter in hue. The higher swelling index and deeper color of the manually roasted *gari* could be attributed to longer roasting time and greater gelatinization of its starch granules, a situation which must have been caused by uncontrolled temperature of fire wood used and the subjective judgments of the processors on when roasting should be concluded.

Table 1 Some properties of *gari*

Property	*Gari* Roasting Method		t-test
	Manual	Mechanical	p
Bulk density kg/m^3	472.74±16.96	469.89±16.21	*0.842
Swelling index	3.69±0.03	3.29±0.23	0.042
Coefficient of uniformity	2.53±0.36	2.89±0.82	*0.318
Colour	2.8Y8.55/2.43 Yellow	5.0GY8.99/10.5 Light yellow	-

* $p > 0.05$ means difference not significant

Results on the proximate compositions of *gari* roasted from the two methods considered in this study and recommended quality specifications by Standards Organization of Nigeria (SON, 2004) are presented in Table 2. The proximate composition of *gari* roasted in the conductive rotary dryer was not significantly different from that of manually roasted *gari* ($p > 0.05$). With the exception of carbohydrate and ether extract, the proximate compositions of mechanically roasted *gari* were slightly higher than those of manually roasted *gari*. The proximate compositions of both products were within the limits recommended by Standards given for *gari* (SON, 2004).

Table 2 Proximate composition of *gari*

Composition %	*Gari* Roasting Method		t-test	SON (2004) Standard
	Manual	Mechanical	p	
Carbohydrate	88.06±1.20	86.80±1.51	*0.402	70% MIN
Moisture	8.44±0.61	8.96±1.47	*0.682	12% MAX
Ash	1.45±0.40	1.69±0.14	*0.369	2.75% MAX
Crude fibre	1.75±0.35	1.82±0.38	*0.846	2% MAX
Crude protein	1.64±0.16	1.88±0.13	*0.133	-
Ether extract	0.42±0.04	0.33±0.16	*0.505	-

*p > 0.05 means difference not significant

Figures 1 and 2 showed the responses on assessment of colour, taste, texture and acceptability of four *gari* samples from the two roasting methods on a Hedonic scale of five, by 15 female and 15 male respondents, respectively. Female and male respondents scored sample 1, sample 2, sample 3 and sample 4 averages of 2.43 and 2.50; 3.6 and 3.86; 3.20 and 3.00 and 4.35 and 4.45, respectively. The assessments of both female and male respondents followed the same trend therefore their judgement and experience with *gari* consumption was assumed to be similar. Sample 4 and sample 2 from mechanically roasted *gari* were rated higher than sample 1 and sample 3 from manually roasted *gari* by all the respondents. The lighter colour of the mechanically roasted *gari* was due to better agitation and controlled temperature. The visual appeal due to the lighter colour must have contributed to respondents' preference for the mechanically roasted *gari*.

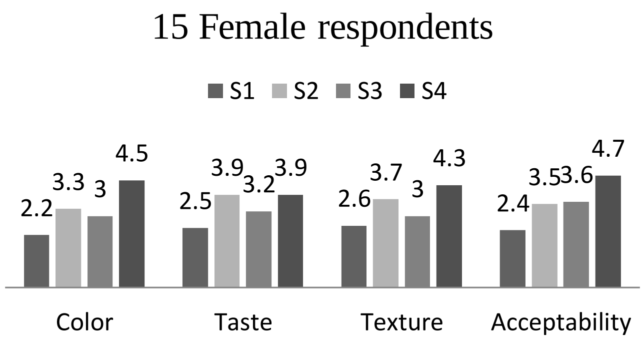

Figure 1 Assessment of sensory properties by female respondents

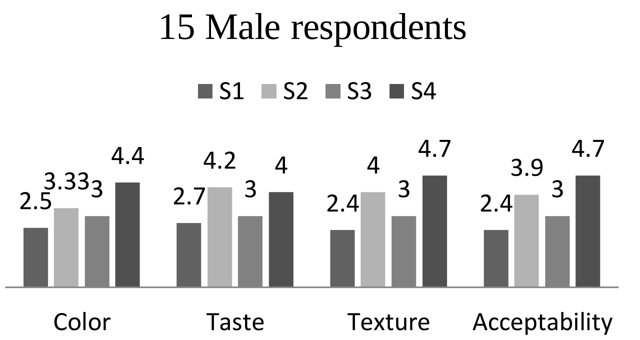

Figure 2 Assessment of sensory properties by male respondents

<u>Legend to Figure 1 and Figure 2:</u>

S1: sample from manually roasted *gari*

S2: Sample from mechanically roasted *gari*

S3: sample from manually roasted *gari*

S4: sample from mechanically roasted *gari*

4 Conclusion

This study compared the quality of *gari* produced from a conductive rotary dryer with that produced by manual roasting method. The results obtained showed that *gari* produced using the conductive rotary dryer compared well with that processed manually in terms of the quality characteristics and sensory properties as well as the proximate composition of the product. Based on the findings of this study, it can be concluded that the mechanically roasted *gari* had better quality characteristics and consumer acceptability than the manually roasted *gari*. The quality of the mechanically roasted *gari* meets local, regional and international standards and it shows that high quality *gari* can be produced at an industrial scale, thereby eliminating the drudgery associated with the traditional manual method and building more technological capacity in the area food process engineering.

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