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Quality assessment of gari produced using a *garifrying* machine

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Abstract

Gari is a major cassava-based food product widely consumed in West Africa. In gari processing, the *garification* stage is critical because it largely determines the quality of the final product, and this operation has recently been mechanized. This study evaluated the quality characteristics of gari produced using a *garifrying* machine and compared them with gari produced using the traditional manual *garification* method. Proximate composition, chemical composition, functional properties, and sensory attributes of the gari samples were determined. Results showed significant differences ($p<0.05$) in ash and moisture contents between the samples. The pH and total titratable acidity values ranged from 3.70–3.82 and 1.36–1.50%, respectively. Hydrogen cyanide contents ranged from 0.12–0.28 mg/kg and differed significantly ($p<0.05$) between the processing methods, although all values were within safe limits for consumption. No significant differences ($p>0.05$) were observed in the functional properties, including swelling index, water absorption capacity, and bulk density, which ranged from 4.16–4.23, 5.05–5.62, and 0.69–0.74 g/cm³, respectively. Sensory evaluation of dried gari, soaked gari, and eba showed that machine-produced gari had comparable sensory acceptability to traditionally processed gari, with improved appearance and overall product uniformity. The study demonstrates that *garification* can be successfully mechanized without adverse effects on gari quality, and the *garifrying* machine shows potential for efficient large-scale gari production.

Keywords: *Gari, Garification, Garifrying machine, chemical composition, functional properties, sensory attributes*

Introduction

Cassava *Manihot esculenta Crantz* is a starchy storage root which is a highly perishable crop and starts to deteriorate within two or three days after harvest if not processed or stored (Babarinsa and Oluwalana 2018). The major cassava food product in Africa is Gari which contribute to about 70% of utilization of cassava for local consumption (Atuna *et al.*, 2021: Ndjouenkeu *et al.*, 2021: Bechoff *et al.*, 2019, Ojiako *et al.*, 2013). Gari is a creamy-white or yellow, granular flour with a faintly fermented flavor and a slightly sour taste made from fermented, gelatinized fresh Cassava tubers. It is consumed as processes or reconstituted with hot water to give a dough-like paste called "Eba", which is consumed with sauce (Babarinsa and Otesile, 2022). Gari is a versatile commodity because its organoleptic characteristic can be adjusted to conform to consumer specifications.

The processing steps consists of washing, peeling and grating the cassava roots, resultant pulp is put in a porous sack (polypropylene bag) and weighed down with heavy object or hydraulic press while it is fermenting. The dewatered and fermented lump of pulp is pulverized, sifted and the resulting semi dried mash is toasted in a pan (Oladipe *et al.*, 2026). Some of the drawbacks of gari processing is that it is time-consuming, it consumes large amounts of fuel in its preparation and safety and health issue which is caused by operator's exposure to smoke and sitting posture (Sobowale *et al.*, 2017: Adegbite *et al.*, 2019; Alabi 2024). This ultimately leads to low output and unhygienic products. Therefore, there is a need for more efficient ways of preparing this product especially the *garifrying* process.

Garification (*Garifrying*) is the most important unit operation in gari production. According to Yadang *et al.*, (2021), it is a combination of simultaneous cooking and drying processes. The dehydration process in *garifrying* is not a straight forward drying process, passing of heat only will produce dried cassava granules and not gari. The product is first cooked with the moisture in it and then dehydrated. During this process, the starch within the flour undergoes partial gelatinization, a process during which the starch granule absorb water, swell and undergo structural changes (Sethi *et al.*, 2022).

Traditionally, small open pans are used for frying, but in an attempt to increase production; larger rectangular pans of up to 2.5 x 1.5m was introduced. Oduro and Clarke (1999) used microwave energy in *garification* while Obadina *et al.*, (2002) used rotary drum dryer. Despite these innovations, their adoption has been limited by high capital cost, dependence on electricity, maintenance challenges, and low commercialization potential.

The *garifrying* machine has emerged as a practical alternative to both traditional frying methods and earlier mechanized systems. It has been used satisfactorily in gari processing and can be fabricated from locally available materials. In addition, it reduces operator discomfort associated with excessive heat and smoke exposure, while improving fuel efficiency and lowering energy consumption per unit of dried gari produced.

Over the years, engineers have developed different types of gari fryers; however, most studies have focused primarily on machine performance rather than the quality attributes of the gari produced. Since product acceptability for both local consumption and export markets is often determined by specific physical and chemical properties, it is essential that any improved processing technology produces gari of acceptable quality while remaining technically feasible. Therefore, this study aimed to compare the quality characteristics of gari produced using traditional frying methods and a commonly used *garifrying* machine.

Materials and Methods

Equipment: The *garifrying* machine (Plate 1) is a simple plant that consists of a semi-circular steel plate with rotating paddles. The paddles are eccentrically located in such a manner that their motion compels the frying gari granules to move from one end of the plate to the other. Drying occurs during this period. Heat is also supplied by fire woods. The paddles are driven by an electric motor through several speed reducers and linkage arrangements. The gang of the paddles oscillates through 180^{o}C at 40 reversals per minute (Plate 1).

Figure 1: A *Garifrying* Machine

Sample preparation: 12 months old cassava roots were harvested from the FUNAAB community. Gari was produced by the process described by Onyekwere *et al.* (2004). The cassava root of was peeled manually using a stainless-steel kitchen knife. The peeled roots were washed and grated in a 5Horze Power diesel powered grater. The grated meal was then packed in large basket and allowed to ferment for 72 hours. The fermented pulp was dewatered using hydraulic press. The pressed cake was broken into pieces with hand and sieved with a wire mesh screen. The sieved pulp was *garified* traditionally i.e using a wide shallow cast iron pot and stirred constantly over a low fire until well dried while the remaining sieved pulp was *garifried* using a *garifrying* machine. It was then be cooled, packaged, labelled and sealed.

Chemical Analysis: The gari samples were analysed for ash, and moisture content according to the method as described by AOAC (2012). Estimation of hydrogen cyanide was done using silver-nitrate volumetric analysis described by Oboh *et al.*, (2002) while the pH and Total titratable acidity (TTA) as lactic acid were determined according to AOAC, (2012). Swelling index, bulk density water absorption Capacity of the sample were determined using the method described by Ukpabi and Ndimele (1990), AOAC (2012) and Ogungbenle *et al.* (2002) respectively. All analysis were in triplicate

Change in temperature during gelatinization determination: The temperature of the initial grated cassava mash is determined, also during the *garification* period, the temperature of the mash is measured at the interval of Five (5) minutes. A 360^{o}C Thermometer was used. The temperature gradient is determined by plotting a graph of Temperature (^{o}C) against Time (Minutes).

Sensory evaluation: The Gari samples were subjected to organoleptic evaluation using 50-man semi-trained panelist for hedonic (acceptability) test this was carried out in the Sensory laboratory, Department of Food Science and Technology, Federal University of Agriculture, Abeokuta. The tests were carried out on consumable form of gari (dried gari, soaked gari and Eba). For dried gari the color aroma, taste and granularity were evaluated, while for soaked gari, the retention capacity, taste and appearance were evaluated and for Eba the level of mouldability, taste, aroma and appearance were evaluated. In each case, the samples were rated according to a 9-point hedonic scale of preference with ratings ranging from 1 (like extremely) and 9 (dislike extremely). The results of the evaluation were then subjected to statistical analysis.

Data analysis: Results from the analysis were subjected to analysis of variance ($p<0.05$) using t-test. Statistical analysis was done using SPSS 17.

Results and Discussion

Ash Content: There were significant differences ($p<0.05$) among the samples, with the gari produced using the *garifrying* machine having an ash content of 0.98±0.19%, while gari produced using the traditional method recorded 1.44±0.01% (Table 1). These values fall within the ranges of 0.12–0.48% and 1.40–1.82% reported by Ojo and Akande (2013) and Kure *et al.* (2012), respectively. Ash content is an index of the total mineral composition of food materials and is influenced by factors such as cassava variety, soil mineral composition, agronomic practices, and processing conditions (Babarinsa and Oluwalana, 2018). During gari production, minerals may be lost through leaching into the expressed liquid during dewatering and fermentation processes. The lower ash content observed in gari produced with the machine may therefore be associated with more efficient pressing and moisture removal during processing. The difference in ash content may also suggest variations in the degree of peeling and possible contamination from processing surfaces during traditional *garifrying*. Traditional *garification* often involves manual handling and contact with metallic or earthen surfaces, which may contribute slightly to residual mineral matter in the final product (Awoyale *et al.*, 2018). Although ash contributes nutritionally by reflecting mineral availability, excessively high ash values may also indicate contamination with extraneous materials such as sand or fibrous residues (Chukwuneke *et al.*, 2020). Therefore, the lower ash value observed in machine-produced gari may indicate improved hygienic handling and better process control.

Table 1: Proximate composition, chemical and functional properties of the different Gari

Quality parameter	*Traditional Method*	*Garifrying Machine Method*
Ash content %	$1.44±0.01^a$	$0.98±0.19^b$
Moisture content%	$10.96±0.42^a$	$7.85±0.23^b$
pH	$3.70±0.00^b$	$3.82±0.02^a$
TTA%	$1.50±0.08^a$	$1.36±0.16^a$
HCN content mg/kg	$0.12±0.00^b$	$0.28±0.01^b$
Bulk density g/cm^3	$0.69±0.02^a$	$0.74±0.03^a$
Swelling index	$4.16±0.33^a$	$4.23±0.33^a$
Water absorption capacity	$5.62±0.11^a$	$5.05±1.21^a$

Values with different superscript letters in the same row are significantly different (p<0.05)

Moisture Content: The moisture content of the gari was significantly affected ($p<0.05$) by the *garifrying* methods. The moisture content of the traditionally processed sample (10.96±0.42%) was significantly higher than that obtained for the sample from the *garifrying* machine (7.85±0.23%). The generally low moisture contents observed are indicative of adequate *garifrying* and drying during *garification* and suggest good keeping quality of the products. However, the rate of drying depends on the efficiency of heat transfer and the ability of the paddles in the *garifrying* machine to ensure uniform movement and mixing of cassava mash during *garifrying*. Longer residence time and improved heat distribution may have enhanced starch gelatinization and moisture evaporation, thereby contributing to the lower moisture content recorded in the machine-processed gari. Moisture content and water activity are important determinants of the microbiological stability and shelf life of food products because high moisture levels favour microbial proliferation and biochemical deterioration (Adejumo and Raji, 2012). The lower moisture content observed in the machine-produced gari therefore suggests a potentially longer shelf stability and reduced susceptibility to mould growth and caking during storage. The moisture content obtained for the machine-produced gari also falls below the 10% maximum limit recommended by the Standard Organisation of Nigeria for safe storage of gari (Sanni *et al.*, 2005). In addition, lower moisture content enhances the crisp texture and overall sensory acceptability of gari during consumption (Abass *et al.*, 2013). The improved moisture reduction observed in the machine method may therefore provide additional technological and commercial advantages in terms of product quality and storage stability.

pH: The *garifrying* methods significantly affected ($p<0.05$) the pH of the gari samples. Gari produced using the traditional method was more acidic, with a pH value of 3.70±0.00, compared to the sample produced using the *garifrying* machine, which had a pH of 3.82±0.02. The obtained values were within the ranges of 3.98–4.01, 3.6–4.0, 4.42–5.98, and 4.65–4.90 reported by Oduro and Clarke (1999), Oduro *et al.* (2000), Sanni *et al.* (2005), and Karim *et al.* (2016), respectively. The pH of gari is strongly influenced by the extent and duration of fermentation prior to *garifrying*. Lower pH values are generally associated with increased production of organic acids such as lactic acid, acetic acid, and other volatile acids by fermentative microorganisms, particularly lactic acid bacteria (Owuamanam *et al.*, 2010). These acids contribute to the characteristic sour taste and aroma of gari, which are important quality attributes preferred by many consumers. The slightly higher pH observed in the machine-produced gari may indicate reduced acid retention due to more rapid *garifrying* and moisture removal during *garification*. A lower pH has also been associated with improved microbial stability and longer shelf life because acidic conditions inhibit the growth of spoilage and pathogenic microorganisms (Karim *et al.*, 2016). However, excessively low pH may adversely affect consumer acceptability in regions where mildly sour gari is preferred. The pH values obtained in this study therefore suggest that both processing methods produced microbiologically stable products within acceptable acidity ranges.

Total Titratable Acidity (TTA): The total titratable acidity (TTA) of the machine-produced sample (1.36±0.00%) was not significantly different ($p>0.05$) from the value obtained for the traditionally processed sample (1.50±0.00%). The TTA values, expressed as percentage lactic acid, were within the ranges of 1.1–1.2%, 0.6–1.2%, and 1.36–1.70% reported by Oduro and Clarke (1999), Oduro *et al.* (2000), and Karim *et al.* (2016), respectively. Titratable acidity is an important quality parameter in fermented cassava products because it reflects the concentration of total organic acids produced during fermentation. Unlike pH, which measures hydrogen ion concentration, TTA provides a broader indication of the total acid load within the product. The slightly higher TTA observed in the traditionally processed gari may be attributed to slower *garifrying* conditions, which may allow greater accumulation and retention of organic acids. The TTA values obtained indicate that adequate fermentation occurred prior to *garifrying*, thereby contributing to the characteristic flavour profile and preservation qualities of gari. Organic acids generated during fermentation not only enhance sensory quality but also play a role in cyanide detoxification and microbial inhibition (Tadesse, 2026).

Hydrogen Cyanide (HCN) Content: There were significant differences ($p<0.05$) in the hydrogen cyanide contents of the samples, with gari produced using the *garifrying* machine having a lower HCN value of 0.12±0.00 mg/kg compared to 0.28±0.01 mg/kg for the traditionally processed gari. These values are far below the maximum safe level of HCN recommended by the Nigerian Industrial Standard and Codex Alimentarius Commission for cassava-based foods intended for human consumption (Sanni *et al.*, 2005). The reduction in cyanide content during gari processing is primarily due to fermentation, dewatering, and *garifrying*, which facilitate enzymatic hydrolysis and volatilization of cyanogenic glucosides (Onabolu *et al.*, 2002). The lower HCN content observed in the machine-produced gari may therefore be attributed to improved heat distribution and more efficient *garifrying* conditions, which enhanced cyanide volatilization. Efficient mixing during machine *garification* may also have promoted uniform heat penetration, thereby reducing residual cyanide levels. Hydrogen cyanide is a critical safety parameter in cassava products because prolonged consumption of inadequately detoxified cassava has been associated with serious health conditions such as konzo and tropical ataxic neuropathy (Oluwole, 2015). The very low HCN values recorded in this study indicate that both processing methods were effective in detoxifying cassava mash to safe levels. Nevertheless, the lower cyanide level in the machine-produced gari suggests that mechanized *garification* may provide additional food safety advantages over traditional *garifrying* methods.

Swelling Index: Results presented in Table 1 showed that there was no significant difference ($p>0.05$) in swelling index between the samples produced by the two *garification* methods. Gari produced using the *garifrying* machine had a slightly higher swelling index (4.23±0.33) than the traditionally processed sample (4.16±0.33). Swelling index describes the ability of gari granules to absorb water and swell during rehydration and is influenced by starch composition, particularly the amylose-to-amylopectin ratio (Olatunde *et al.*, 2021). Swelling index is an important functional property because it reflects the degree of starch gelatinization and the reconstitution characteristics of gari. Higher swelling values indicate weaker associative forces within starch granules, allowing greater water penetration and expansion (Sanni *et al.*, 2001). The values obtained in this study compare favourably with the Codex Alimentarius recommendation of 3.0 and with the ranges of 2.7–3.3, 3.3–4.5, and 3.0–4.5 reported by Oduro and Clarke (1999), Ojo and Akande (2013), and Karim *et al.* (2016), respectively. The slightly higher swelling index observed in machine-produced gari may be related to more uniform heat application during *garifrying*, which could have enhanced starch gelatinization. High swelling capacity is desirable because it improves the texture and mouthfeel of reconstituted gari products such as *eba* and soaked gari.

Bulk Density: The bulk density of the samples did not differ significantly ($p>0.05$), the gari produced using the traditional method was 0.69±0.02 g/cm³, while gari produced using the machine method had a slightly higher value of 0.74±0.03 g/cm³. These values were higher than the ranges of 0.50–0.58 g/cm³ and 0.53–0.67 g/cm³ reported by Kure *et al.* (2012) and Karim *et al.* (2016), respectively. Bulk density is an important physical property that influences packaging, transportation, storage, and consumer perception of food products. It is affected by particle size, porosity, starch content, and degree of compaction (Barbosa-Cánovas and Juliano, 2005). The slightly higher bulk density observed in machine-produced gari may be attributed to the production of more uniformly sized particles during mechanized *garifrying* and stirring. High bulk density is advantageous because it increases packaging efficiency and reduces storage space requirements. It also affects the dispersibility and reconstitution behaviour of gari in water during preparation of *eba* (Awoyale *et al.*, 2021). The values obtained in this study suggest that gari produced using the *garifrying* machine possesses desirable handling and packaging characteristics suitable for commercial production.

Water Absorption Capacity (WAC): The water absorption capacity of the gari samples was not significantly affected (p>0.05) by the *garifrying* methods. The water absorption capacity of the traditionally processed gari (5.62±0.11) was slightly higher than that of the machine-produced gari (5.05±1.21). These values were lower than the ranges of 7.70–8.16 and 5.7–7.5 reported by Kure *et al.* (2012) and Karim *et al.* (2016), respectively. Water absorption capacity reflects the ability of starch and other hydrophilic constituents within gari to bind water through hydrogen bonding (Gaila *et al.*, 2020). Therefore, higher water absorption values indicate a greater number of available hydrophilic sites for water binding. The slightly higher water absorption capacity observed in traditionally processed gari may be associated with differences in starch granule disruption and particle structure resulting from *garifrying* conditions. Excessive heat exposure during machine *garification* may have caused partial collapse of starch granules, thereby reducing their water-binding ability. Nevertheless, the relatively high water absorption capacities observed in both samples indicate good reconstitution properties and suitability for preparation of dough-like products such as *eba*.

Change in temperature during *Garification*

There is no significant difference p>0.05 in the pattern of the change in temperature during granulation. The temperature gradient of the traditional (1.88) (Figure 2) is slightly greater than that of the machine (1.46) (Figure 3). There was a constant increase in temperature for the first five minutes. *Garification* is a combination of simultaneous cooking and drying processes, so drying takes place at the higher temperature (above 80^{o}C) as seen in Figure 2 and 3. It should also be noted that the ratio of fire wood used in the machine as compared to the traditional method was in the ratio 5 to 1 respectively, while the mass of cassava mash of machine to traditional was in a ratio 15:1 respectively. However, in terms of the quality *garifried* per batch, the *garifrying* machine would be considered more efficient in energy utilization.

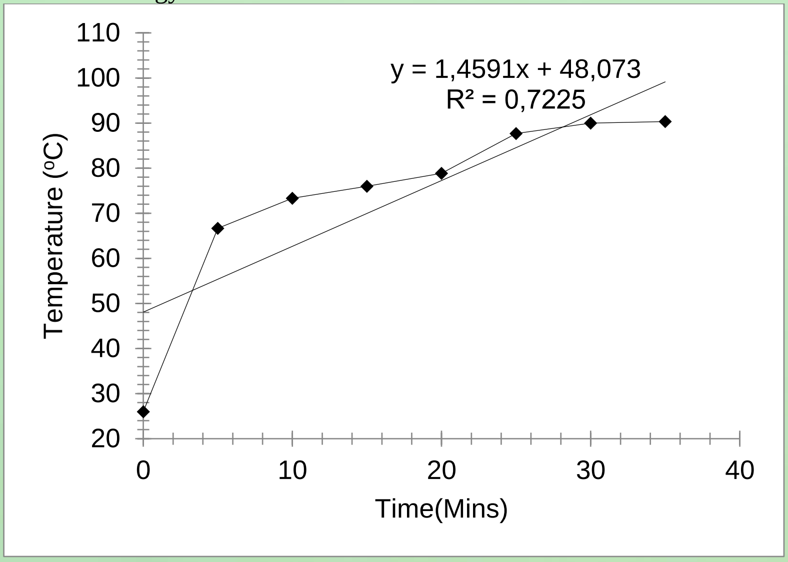

Figure 2: Change in temperature during *Garification* in *garifrying* machine

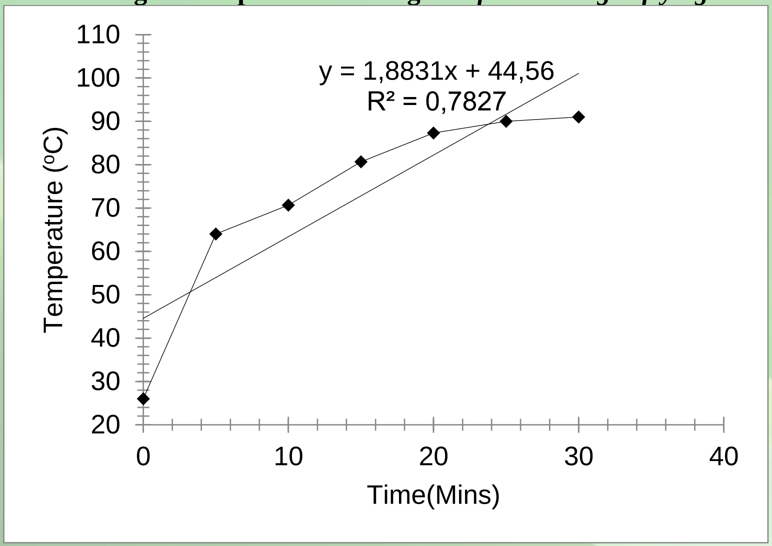

Figure 3: Change in temperature during *Garification* in Traditional frying method

Sensory Evaluation

Sensory Evaluation of Dried Gari: The sensory evaluation results for dried gari are presented in Table 2. Significant difference ($p<0.05$) was observed only in appearance (colour). Gari produced using the *garifrying* machine was preferred in terms of appearance (2.11±0.87) and granularity (2.49±1.37) compared to the traditionally processed sample (3.20±1.73 and 2.57±1.65, respectively). The improved appearance of the machine-produced gari may be attributed to the more uniform heat distribution and continuous agitation provided by the *garifrying* machine. This agrees with the lower moisture content earlier observed in the machine-produced gari, which may have contributed to a drier, crisper, and more visually appealing product. Granularity is an important sensory quality parameter because consumers generally prefer gari with uniform particle size and smooth texture (Ngoualem Kégah and Ndjouenkeu, (2023). The slightly better granularity score recorded for the machine-produced gari suggests that mechanized *garification* enhanced particle uniformity during *garifrying*. The higher bulk density earlier reported for the machine sample may also be associated with improved compactness and particle consistency. However, the aroma and taste of the traditionally processed gari (2.63±1.09 and 2.11±1.18, respectively) were preferred over those of the machine-produced sample (3.09±1.17 and 2.23±0.91, respectively). This preference may be due to the stronger flavour and sourness developed during traditional *garification*. Traditional *garifrying* often involves slower heating and direct contact with heated surfaces, which may favour Maillard reactions and the formation of characteristic volatile compounds responsible for the typical gari aroma. In addition, the slightly lower pH and higher titratable acidity previously observed in the traditional sample may have enhanced the characteristic sour taste preferred by consumers.

Table 2: Hedonic Rating for sensory attribute of dried gari

QUALITY PARAMETER	*TRADITIONAL*	*MACHINE*
COLOUR	3.2±1.73a	2.11±0.87b
TASTE	2.11±1.18a	2.23±0.91a
GRANULARITY	2.57±1.65a	2.49±1.37a
AROMA	2.63±1.09a	3.09±1.17a

Values with different superscript letters in the same row are significantly different ($p<0.05$)

Sensory Evaluation of Soaked Gari: The sensory evaluation results for soaked gari are presented in Table 3. There were no significant differences ($p>0.05$) among the sensory attributes evaluated for the soaked gari samples. The appearance of the machine-produced soaked gari (2.29±1.10) was preferred over that of the traditional sample (2.65±1.28). This observation may be linked to the improved colour and granularity of the machine-produced dried gari observed earlier. Uniform granule structure and lower moisture content may have enhanced the visual quality of the soaked gari. The traditionally processed gari recorded slightly better taste (2.29±1.59) and retention capacity (2.38±1.02) than the machine-produced sample (2.66±1.39 and 2.49±1.22, respectively). Retention capacity refers to the ability of gari granules to maintain their integrity without rapid disintegration during soaking. The slightly better retention ability of the traditional sample may be related to differences in starch structure and gelatinization behaviour developed during *garifrying*. The relatively higher water absorption capacity earlier observed in the traditional sample may also have contributed to improved hydration and mouthfeel during soaking. The preference for the taste of the traditionally processed soaked gari may similarly be associated with its slightly higher acidity and stronger fermentation-derived flavour compounds.

Table 3: Hedonic Rating for sensory attribute of Soaked Gari

QUALITY PARAMETER	*TRADITIONAL*	*MACHINE*
RETENTION CAPACITY	$2.38±1.02^{a}$	$2.49±1.22^{a}$
TASTE	$2.29±1.59^{a}$	$2.66±1.39^{a}$
APPEARANCE	$2.65±1.28^{a}$	$2.29±1.10^{a}$

Values with different superscript letters in the same row are significantly different ($p<0.05$)

Sensory Evaluation of *Eba* (Gari Stiff Paste): The sensory evaluation results for *eba* prepared from the gari samples are shown in Table 4. Significant difference ($p<0.05$) was observed only in mouldability. *Eba* produced from traditionally processed gari had better mouldability (2.45±1.02), taste (2.41±1.40), and aroma (2.72±1.69) than *eba* prepared from machine-produced gari (3.29±1.79, 3.11±1.43, and 2.74±1.20, respectively). Mouldability is an important quality attribute of *eba* because it determines the ease with which the paste can be shaped, handled, and consumed. The superior mouldability observed in *eba* from traditionally processed gari may be attributed to differences in starch gelatinization, swelling behaviour, and water absorption characteristics during cooking. The slightly higher water absorption capacity recorded for the traditional sample may have enhanced the cohesiveness and elasticity of the resulting paste. Similarly, the preference for the taste and aroma of *eba* from traditionally processed gari may be associated with stronger fermented and roasted flavour notes retained during traditional *garifrying*. The lower pH and higher titratable acidity earlier observed in the traditional sample may also have contributed to the characteristic sour flavour preferred by panelists. However, the colour of *eba* prepared from machine-produced gari (2.14±1.31) was preferred over that from traditional gari (2.55±1.48). This further supports the earlier observation that controlled and uniform heating during mechanized *garification* improved the appearance of the final product.

Table 4: Hedonic Rating for sensory attribute of Eba (Gari paste)

QUALITY PARAMETER	*TRADITIONAL*	*MACHINE*
MOULDABILITY	2.45 ± 1.02^{b}	3.29 ± 1.79^{a}
TASTE	2.41 ± 1.4^{a}	3.11 ± 1.43^{a}
AROMA	2.72 ± 1.69^{a}	2.74 ± 1.20^{a}
APPEARANCE	2.55 ± 1.48^{a}	2.14 ± 1.31^{a}

Values with different superscript letters in the same row are significantly different ($p<0.05$)

Conclusion

Gari produced using the *garifrying* machine compared favourably with traditionally processed gari and complied with recommended quality standards. The machine-produced gari showed improved moisture reduction, lower hydrogen cyanide content, better appearance, and acceptable sensory properties. These findings indicate that *garification* can be successfully mechanized without adversely affecting product quality. The *garifrying* machine therefore offers a promising alternative for efficient and large-scale gari production.

Declarations

Ethical Approval Certificate

The objectives and significance of the study were thoroughly explained to all participating panelist before obtaining informed consent. Participants were fully informed of the study's purpose, procedures, and implications. Each participant voluntarily agreed to take part in the sensory evaluation after understanding their right to withdraw at any stage without consequences. Informed consent was obtained verbally and in writing to ensure that participants are fully aware of their involvement.

Author Contribution Statement

Olumuyiwa Babarinsa: Conceptualization, project administration, visualization methodology, software and writing of the original draft, reviewing, and editing of the manuscript. **Ibijoke Otesile**: Data curation, formal analysis, investigation, methodology, writing the original draft, reviewing, and editing of the manuscript. **Omolola Omosebi:** reviewing, and editing of the manuscript. **Ajibola Oyinloye:** Investigation, methodology, writing, reviewing, and editing.

Conflict of Interest

The authors declare no conflict of interest

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