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Quality Characteristics of Gari as Affected by Preferment Liquor, Temperature and Duration of Fermentation

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ABSTRACT

The effect of preferment liquor, temperature and duration of fermentation on the cyanide content as well as the functional and sensory properties of gari were studied. Cassava roots (local cassava variety) were peeled washed and grated and immediately seeded with 3-day spent liquor concentrations (0.0, 5.0, 10.0, 15.0 and 20.0% (m/v)) in thoroughly washed plastic containers. These were kept in ambient environment ($\pm 30^{\circ}\text{C}$) to ferment; samples were with drawn at 12, 24, 36, 48 and 72 h intervals and processed into gari. The processes were repeated for controlled fermentation at 35 and 40°C using a water bath. The samples were analyzed for pH, titratable acidity, residual cyanide and sensory evaluation (taste, appearance and general acceptability). The results show that increasing concentration of spent liquor significantly lowered residual cyanide, decreased pH and increased the titratable acid. The addition of preferment reduced the HCN concentration to 9.92 mg HCN kg⁻¹ for 15.0% and 8.36 mg HCN kg⁻¹ for 20.0% samples. Similarly, 15% preferment liquor, gave the highest swelling index-26.19 when, fermented at 30°C. However, the value decreased to 23.12 and 22.71 when fermented at 35 and 40°C. The sample fermented at 5.0% gave the best performance (0.6047 g cm⁻³) for the bulk density. The sample from 5.0% preferment treatment also gave the best performance in terms of appearance (6.0), taste (6.1) and general acceptability (6.1). The titratable acidity increased with increase in preferment concentration. Moreover, limiting the spent liquor to 5.0%, temperature, at 35°C and duration of fermentation, at 48 h gave best performance for functional and sensory qualities and also guarantees food safety.

Key words: Cassava, seed liquor, cyanide, titrable acidity, functional properties, sensory properties

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is Africa's second most important food staple in terms of per capital calories consumed (Nweke *et al.*, 2002). The crop is being relied upon to provide the food need of Africa's growing population projected to double to 1.2 billion by 2020 and coupled with urban population which grows at a faster rate (World Bank, 2000). Gari, is a granulated cassava product, which is cherished by urban consumer because of its convenience, long shelf life and its ready-to-eat form (Ngoddy, 1977; Ernesto *et al.*, 2000; Onabolu, 2001; Ajala *et al.*, 2008). Gari is produced traditionally by grating peeled cassava root, dewatering the resultant pulp and roasting the dewatered fermented product (Sokari and Karibo, 1992). The processing of gari is

labour-intensive and women provide the manual labour for the task (Nweke *et al.*, 2002; UNDP, 2005). Fapojuwo (2008) gave statistical index of women cassava processors' roles in enhancing household food security in Southwest Nigeria.

Several efforts made at large scale production of gari in Nigeria failed because the processing plants could not understand the principles of fermentation and detoxification of cyanogenic glucoside in cassava (Achinewhu and Owuamanam, 2001; Nweke *et al.*, 2002). Fermentation essentially impacts taste to gari (Vasconcelos *et al.*, 1990). While detoxification is mediated by endogenous linamarase and hydroxyl nitrile lyase on linamarin and lotuastralin to yield hydrogen cyanide (Dixon *et al.*, 1994). Cyanide reduction is the centre issue in cassava being a food security crop in Nigeria (Adebayo, 2006; Sanni, 2005). Nwachukwu and Edward (1989) reported that fermentation softens the fermenting mash thereby facilitating the liberation of hydrogen cyanide-a known plant toxin. This study investigates, the influence of preferment liquor concentrations, varying process temperature and duration of fermentation on cyanide reduction in gari and implications of these variables on the physicochemical and sensory characteristics of gari. It is also expected to provide a window for successful large scale processing of gari.

MATERIALS AND METHODS

The cassava roots used in this study were from a local variety nwanyi bekee harvested from the farms of Federal University of Technology, Owerri, Nigeria in the month of November 2008.

Preparation of process reagent: Two hundred grams peeled cassava roots were soaked in water at ambient temperature ($\pm 30^{\circ}\text{C}$) for 3 days. The spent liquor was collected, analyzed (Table 1) and used as process reagent for the fermentation of cassava mash into gari.

Generation of samples: Freshly harvested cassava roots were peeled, washed and grated. The preferment liquor was quickly introduced into 500 g cassava mash at concentrations: 0.0, 5.0, 10.0, 15.0 and 20.0% (mass/volume). The cassava mash was well mixed with the spent liquor and finally put into plastic container and left to ferment at ambient temperature (30°C). Samples were withdrawn at intervals of 12, 24, 36, 48 and 72 h, dewatered, sifted and toasted into gari. The process runs were repeated for controlled fermentation at 35, 40°C using water bath. The samples were analyzed for the physicochemical properties (Swelling Index (SI), pH, Titratable Acidity (TTA), Water Absorption Capacity (WAC) and residual cyanide (HCN)) and also sensory evaluation.

pH determination: The pH of the sample of gari was determined using the method of Association of Official Analytical Chemists (AOAC, 1990). Ten grams of the sample was put into 100 mL beaker

Table 1: pH and microbial property of the preferment liquor

Period of fermentation (h)	pH of mash	Bacterial counts	Total yeast counts	Micro organisms isolated from fermenting mash
0	5.6	2.4×10^5	1.9×10^4	<i>Leuconostoc</i> sp., <i>Alcaligenes</i> sp., <i>Corynebacteria</i> sp., <i>Candida</i> sp.
24	5.4	1.2×10^7	4.1×10^4	<i>Leuconostoc</i> sp., <i>Alcaligenes</i> sp., <i>Streptococcus</i> sp., <i>Lactobacillus</i> sp., <i>Corynebacteria</i> sp., <i>Candida</i> sp.
48	4.8	8.0×10^7	6.5×10^5	<i>Leuconostoc</i> sp., <i>Lactobacillus</i> sp., <i>Streptococcus</i> sp., <i>Candida</i> sp.
72	4.6	5.5×10^8	7.0×10^5	<i>Leuconostoc</i> sp., <i>Lactobacillus</i> sp., <i>Candida</i> sp.

and 100 mL of distilled water added to it. The pH was analyzed using a standardized pH meter (Prazisions pH meta ES10 model). Triplicate values were obtained and the mean taken as the pH value.

Total titratable acidity (TTA): The percent titratable acidity was determined following the method of FAO (1970). Five grams of the sample was dissolved in a beaker and made up to 100 mL with distilled water and allowed to stand for 30 min. The solution was filtered with whatman filter paper. Twenty five milliliter of the filtrate was titrated against 0.1 M NaOH, using phenolphthalein as indicator. The end point was obtained when the colour became colourless. The mean (TTA) was obtained from triplicate determination. The percent Titratable Acidity (TTA %) was calculated using the formula:

$$\text{TTA (\%)} = 0.005X \times 100 \times 1000 = 0.01X$$

where, X is the mean titre value.

Swelling index: The method of Ukpabi and Ndimele (1990) was followed with slight modification. Ten grams of the sample was transferred into a clean, dried, calibrated measuring cylinder. The gari was gently leveled by tapping the cylinder and the initial volume recorded. Fifty milliliter of distilled water was poured into the cylinder and allowed to stand for 4 h. The value for Swelling Index (SI) was taken as the multiples of the original volume.

Water Absorption Capacity (WAC): The method of Sosulski (1962) as described by Abbey and Ibeh (1988) was followed. One gram of gari was weighed into an already weighed clean dried centrifuge tube. Twenty milliliter of distilled water was poured into the centrifuge tube and stirred thoroughly; centrifuge at a speed of 3500 rpm for 45 min. The supernatant was discarded and the tube and its content reweighed. The gain in mass was taken as the water absorbed.

Bulk density: The method of Akpapunam and Markakis (1981) was followed. Ten grams of the gari were transferred into 50 mL measuring cylinder. The cylinder was tapped repeatedly for 5 min. The bulk density of gari was calculated as the mass of gari over the volume at the end of tapping. The mean value was recorded from triplicate determinations.

Determination of residual hydrogen cyanide

Equipments and reagents: The residual cyanide content of gari was determined using the method of Essier *et al.* (1993). Equipments: Cap fit test tubes, automatic pipettes, pH meter, water bath, spectrophotometer (visible), analytical balance, steamer etc. Reagents: 0.1 M orthophosphoric acid, 0.1 M phosphate buffer pH 6.0, 7.0, acetate buffer, pH 4.0, 0.2 M NaOH, 0.5% chloramine-T, Potassium cyanide (KCN), colour reagent made by dissolving 3.5 g NaOH in 200 mL water and added 7.0 g of 1, 3-dimethyl barbituric acid and 5.7 g isonicotinic acid and stirred several times and then adjusted the pH to 7.5 with acetone etc.

Preparation of enzyme linamarase from freshly harvested roots: Freshly harvested cassava roots were peeled to remove the cortex. The cortex was shredded to small pieces of about 1 cm in size and refrigerated after wards. Twenty five grams of the shredded cortex was homogenized with

250 mL of 0.1 M acetate buffer pH 5.5. The homogenate was filtered through cheese cloth. The filtrate was used to homogenize another batch of 25 g of cortex and again on the third batch. A total of 1 L of the extract was prepared and stored in the refrigerator.

Preparation of KCN standard: A stock solution was prepared by dissolving 50 mg of KCN in 0.2 M NaOH. The stock solution was diluted 1:50 with 0.2 M NaOH. The automatic pipette was used to pipette into marked tubes: 0.025, 0.050, 0.075 and 0.100 mL of the diluted KCN stock, the volume was made up to 0.100 mL corresponding to 5, 10, 15 and 20 $\mu\text{g mL}^{-1}$ with 0.2 M NaOH. The 0.5 mL of 0.1 M phosphate buffer pH 6.0 was added followed by addition of 0.6 mL, chloramines-T and 0.8 mL of the colour reagent. The absorbance reading was obtained using (visible) spectrophotometer against blank at 605 nm wavelength.

Determination of cyanide in gari: Thirty grams of gari was milled and homogenized with 250 mL of 0.1 M orthophosphoric acid. The homogenate was centrifuged. The supernatant was taken as the extract; 0.1 mL of the enzyme was added into 0.6 mL of the extract. The 3.4 mL of the acetate buffer (pH 4.5) was added and stirred to mix. After which 0.2 mL of 0.5% chloramin-T and 0.6 mL of colour reagent were added and allowed to stand for 15 min. for colour development. The absorbance value was obtained at 605 nm against a blank similarly prepared containing all reagents and 0.1 mL phosphate buffer added instead of KCN.

Calculation: The data from the standard were used to obtain a standard curve and its slope (b) by plotting absorbance values (Y-axis) against standard concentrations (X-axis). The unknown mean absorbance (A) and the weight of the sample (w) were used to calculate the residual cyanide, using the formula: Residual cyanide = $A \times 250 \times 0.4151 \div b \times w$ and the unit in mg HCN equivalent kg^{-1} sample.

Sensory evaluation of gari: Sensory evaluation was conducted to determine consumer preferences, using a 9-point hedonic scale as described by Watt *et al.* (1989) for the degree of likeness. Nine represented like extremely, mid point 5 represents neither like nor dislike and runs down to one which represented dislike extremely. The parameters assessed include; appearance, taste and general acceptability. Twenty member panelists were used and samples were presented to them in clean dried plates.

Statistical analysis: The results of the physicochemical parameters were analyzed as a function of preferment concentration (5) \times fermentation temperature (3) \times durations of fermentation (5) which fitted into 3-way analysis of variance and the means separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Physicochemical properties of gari as affected by varying concentration of preferment:

The physicochemical properties of gari as affected by preferment concentrations are shown in Table 2. The pH of the samples were significantly affected by the Preferment Concentrations (PC) under the condition of study ($p < 0.05$). The treatment of cassava mash with preferment liquor did not translate to drastic reduction in the final pH of the resultant gari. However, the mean pH obtained by varying concentration of preferment compared well with the control. It may be suggested that addition of spent liquor might not have negative consequence in the pH of gari.

Table 2: Mean value of physicochemical properties of gari as affected by preferment concentration

Conc. of preferment	pH	SI (mL)	% TTA	BD (g cm ⁻³)	WAC (mL g ⁻¹)	HCN (mL kg ⁻¹)
0	4.58±0.52 ^a	21.61±3.31 ^a	0.049±0.03 ^e	0.5447±0.18 ^b	1.33±0.44 ^b	25.45±4.94 ^a
5	4.38±0.21 ^b	22.44±2.32 ^a	0.066±0.02 ^d	0.6047±0.01 ^a	1.44±0.34 ^a	18.77±2.92 ^b
10	4.32±0.21 ^{bc}	22.39±2.03 ^a	0.072±0.01 ^c	0.5993±0.02 ^a	1.40±0.40 ^{ab}	12.57±2.38 ^c
15	4.26±0.21 ^{cd}	26.19±1.42 ^a	0.079±0.01 ^b	0.5987±0.02 ^{ab}	1.30±0.34 ^b	9.92±1.63 ^d
20	4.19±0.25 ^d	22.18±2.16 ^a	0.066±0.02 ^a	0.6000±0.02 ^a	1.15±0.49 ^c	8.36±1.33 ^e
LSD	0.1194	5.265	0.0039	0.0419	0.1117	0.8368

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at $p \leq 0.05$

The Swelling Index (SI ml mL⁻¹) of the samples did not differ under the condition of study $p > 0.05$. The addition of preferment liquor in cassava mash had moderate effect on the swelling index as shown by the superior mean value obtained from treated samples over the control in Table 2. However, the values obtained from gari fermented with preferment were within the range obtained by Sanni (1990). The highest swelling index, 26.19 obtained for gari from 15.0% preferment liquor, might suggest that 15% preferment liquor would give the best performance when adding preferment is a considered option for gari quality. Swelling index reflects the extent of associative forces within the granules, thus, the higher the swelling index the lower the associative force (Sanni *et al.*, 2001). Consumers demand gari with good swelling power.

The Titratable Acidity (TTA) of the gari was significantly affected by the preferment concentration. The titratable acidity of the control sample was not superior to values obtained for the samples treated with preferment liquor. It might be suggested that the introduction of the preferment interfered with the microbial flora of the ferment thus eliminating some microorganisms that could have aided in the production of acids. Moreover, the TTA of the treated samples compared well with those obtained through traditional fermentation (Achinewhu and Owuamanam, 2001).

It was observed that all the samples treated with preferment did not differ ($p > 0.05$) in their bulk densities. However, the bulk density of the treated samples differed significantly with the control, suggesting that bulk density as a quality parameter is improved by addition of preferment. The improvement of bulk density of treated sample might be that presence of preferment affected the utilization of sugar by micro organisms.

The water absorption capacity, WAC (mL g⁻¹ solid db) were significantly affected by the preferment at $p < 0.05$. The trend shows decreasing value of water absorption capacity with increasing strength of preferment. However, at levels of 10 and 15% the absorption capacity did not differ significantly ($p > 0.05$). Adding preferment according to the result does not improve water absorption capacity of gari. Thus, the water absorption capacity of the treated samples compared well with those obtained by Achinewhu and Owuamanam (2001).

Increasing preferment concentration positively and significantly affected the reduction of hydrogen cyanide concentration in the samples ($p < 0.05$). The significant reduction in residual cyanide was observed among the samples from cassava mash seeded with preferment liquor. The addition of preferment reduced the HCN concentration to 9.92 mg HCN kg⁻¹ for 15% and 8.36 mg HCN kg⁻¹ for 20% (Table 2), respectively which are below the recommended level of 10 mg HCN kg⁻¹ considered safe (FAO/WHO, 1999). The studies by Adindu *et al.* (2003) and Adindu and Aprioku (2006) revealed that cassava products including gari sold in River State Nigeria contained total cyanide higher than 10 ppm recommended for cassava flour. Bradbury (2004) had proposed processing as a suitable strategy to cyanide reduction in cassava products. The

Table 3: Mean value of physicochemical properties of gari as affected by fermentation temperature

Fermentation temp. (°C)	pH	SI (mL)	% TTA	BD (g cm ⁻³)	WAC (mL g ⁻¹)	HCN (mL kg ⁻¹)
30	4.31±0.49 ^b	23.12±1.17 ^a	0.078±0.03 ^a	0.6160±0.0 ^a	0.86±0.22 ^c	15.74±7.32 ^a
35	4.44±0.22 ^a	23.00±1.40 ^a	0.064±0.02 ^c	0.5552±0.137 ^b	1.50±0.23 ^b	15.08±6.46 ^b
40	4.29±0.14 ^b	22.77±1.37 ^a	0.068±0.02 ^b	0.5972±0.02 ^a	1.62±0.23 ^a	14.22±7.28 ^c
LSD	0.0925	4.078	0.0865	0.6482	0.003	0.0419

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at $p \leq 0.05$

capacity of added preferment liquor in reducing the cyanide content might be that it opens the cellular structure of cassava mash, allowing cyanide to be liberated off and vaporized as suggested by Sokari and Karibo (1992). The reduction of cyanide in preferment liquor may be due to autolytic conversion of non-volatile cyanohydrin to HCN, which become rapid by the opening of cell structure of the mash (Sokari and Karibo, 1992).

Physicochemical properties of gari processed by treatment with preferment as affected by temperature of fermentation (FT): The result of physicochemical properties of gari as affected by fermentation temperature is shown in Table 3. The mean pH recorded for the various fermentation temperatures differed significantly at $p < 0.05$. Fermenting cassava mash into gari at 30, 35 and 40°C did not remarkably affect the pH of the resultant gari. In effect, it is possible that the temperature regimes were conducive for the activities of microorganisms responsible for fermentation.

The swelling index did not differ as the fermentation temperature increased; however, the best performance (SI 23.12 ml mL⁻¹) was obtained at 35°C while the 40°C had the least SI (22.77 ml mL⁻¹). This shows that swelling capacity of gari would not vary as a result of variation in fermentation temperature. In contrast, the mean TTA differed at $p < 0.05$ with variation in fermentation temperature.

The titratable acidity, bulk density, water absorption capacity were marginally increased with elevation of process temperature. The Bulk Density (BD) g cm⁻³ of the samples were significantly affected by variation in fermentation temperature. The sample from 30°C had the best performance, BD = 0.616 g cm⁻³ while, the FT = 35°C had the least mean BD, 0.5 552 g cm⁻³. However, the performance of the sample from FT = 30°C did not differ from that of FT = 40°C. The highest Water Absorption Capacity (WAC) (1.62 mL g⁻¹ solid) was recorded for the sample fermented at 40°C while the least WAC (0.86 mL g⁻¹ solid) was recorded for the FT = 30°C. Similarly, the mean mg HCN kg⁻¹ of the gari differed significantly at $p < 0.05$. The least HCN (14.22 mg HCN kg⁻¹) was obtained from FT = 40°C while the highest (15.74 mg HCN kg⁻¹) was recorded for FT = 30°C. It might be reasoned that increasing temperature of fermentation reduced the residual cyanide of the samples significantly. Sokari and Karibo (1992) obtained losses in bound cyanide of 25, 27 and 33%, when cassava mash were held at 30, 35 and 40°C, respectively. It is possible that elevating the fermentation temperature aids the volatilization of liberated cyanide which might otherwise be trapped within the matrix of gari. It is also possible to achieve about 84-95% reduction of cyanide in gari when with certain strains of fungi (Sokari and Mepba, 2008).

Physicochemical properties of gari processed by treatment with preferment as affected by duration of fermentation (FT): The physicochemical properties of samples of gari as affected by Duration of Fermentation (DF) were as shown in Table 4. Least mean pH was obtained for

Table 4: Mean value of physicochemical properties of gari as affected by Durations of Fermentation (DF) in preferment

Fermentation (h)	pH	SI (mL)	% TTA	BD (g cm ⁻³)	WAC (mL g ⁻¹)	HCN (mL kg ⁻¹)
12	4.62±0.41 ^a	24.77±12.50 ^a	0.499±0.02 ^e	0.5900±0.02 ^a	1.51±0.54 ^a	18.61±8.58 ^a
24	4.50±0.29 ^b	23.25±1.14 ^a	0.063±0.02 ^d	0.5980±0.02 ^a	1.33±0.39 ^b	16.09±7.52 ^b
36	4.35±0.13 ^c	24.00±0.90 ^a	0.069±0.02 ^c	0.6053±0.02 ^a	1.25±0.30 ^b	14.39±6.20 ^c
48	4.25±0.17 ^c	22.08±0.87 ^a	0.076±0.02 ^b	0.5713±0.13 ^a	1.30±0.34 ^b	13.53±5.94 ^d
72	4.02±0.21 ^d	20.73±1.09 ^a	0.090±0.02 ^a	0.5827±0.13 ^a	1.26±0.42 ^c	12.45±5.24 ^e
LSD	0.1194	5.265	0.0039	0.0419	0.1117	0.8368

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at $p \leq 0.05$

72 h (4.02) fermentation while the highest pH (4.62) was recorded for 12 h (DF) The significant decrease in pH of gari produced from cassava mash as fermentation duration increased is supported by the fact that microbial activities increase with time, thus, resulting to increase in metabolites (organic acids) production. Several authors have emphasized the need for fermentation of cassava mash up to 48 h (Achinewhu *et al.*, 1998; Achinewhu and Owuamanam, 2001).

As expected, the TTA increased with increase in fermentation hour which corroborated the decrease in pH earlier explained. However, the values were low when compared with values obtained by Achinewhu and Owuamanam (2001). The highest BD in Table 4 was obtained from 36 h fermentation (0.6053 g cm⁻³) while the least BD (0.5713 g cm⁻³) was recorded for 48 h fermentation.

Also, the data for swelling index (SI), shows that the sample from DF = 12 h; had the highest mean SI (24.77 ml mL⁻¹) while the least mean SI was obtained for DF = 72 h (20.73 ml mL⁻¹). The gradual but significant reduction in swelling index with duration of fermentation, might suggest that microorganisms were able to break structure of macromolecules as fermentation progresses (Achinewhu *et al.*, 1998). Similar decreasing trend in the Water Absorption Capacity (WAC) was observed for the samples in Table 4. The superiority of the WAC and SI for 12 h fermented gari need to be further investigated as they might offer possible reasons why some processors adopt shortened fermentation time. Shortened fermentation time has been found to retain high level of residual cyanide in gari with its serious health implications (Rosling, 1988; Tylleskar *et al.*, 1993). The mean residual cyanide (HCN) among the samples, decreased as the duration of fermentation increased. The least residual HCN was obtained from DF = 72 h, (12.45 mg HCN kg⁻¹), which strengthens the need to ferment gari for at least 48 h (Achinewhu and Owuamanam, 2001).

The sensory evaluation of gari as affected by preferment liquor concentration: The result of sensory evaluation of gari as affected by preferment concentration is as shown in Table 5. The sample from 5.0% preferment with highest mean score (6.0) was adjudged the best by the panelists with respect to appearance. Appearance is a major factor considered in for acceptance of gari by consumers (Ajala *et al.*, 2008). It was found that adding preferment to cassava mash did not improve the appearance of gari, rather the appearance became poorly rated at high levels of preferment liquor. However, Oni *et al.* (2008) observed a correlation between functional properties and sensory properties of cassava products.

The taste of gari was significantly affected by preferment liquor ($p < 0.05$) as shown in Table 5. Incidentally, the gari from 5.0% (6.1) was highly preferred by the panelists, followed by 10.0% (6.0) while the least preferred came from 20% (5.1). The result obtained might suggest that limiting the preferment at 5.0% impact the desired taste in gari. The taste became less agreeable to the palate when the 5.0% preferment is exceeded as indicated by the gradual decline in mean sensory value

Table 5: Mean value of sensory properties of gari as affected by concentration of the preferment

Conc. of preferment % (m/v)	Appearance	Taste	General acceptability
0	5.8±0.69 ^a	5.7±0.78 ^b	5.7±0.55 ^b
5	6.0±0.59 ^a	6.1±0.69 ^a	6.1±0.53 ^a
10	5.9±0.71 ^a	6.0±0.55 ^a	5.4±0.52 ^c
15	5.8±0.55 ^a	5.5±0.49 ^c	5.4±0.44 ^c
20	5.3±0.559 ^b	5.1±0.64 ^d	4.8±0.55 ^d
LSD	0.2596	0.2346	0.1616

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at ≤ 0.05

Table 6: Mean values of sensory properties of gari as effected by temperature of fermentation

Temp of fermentation (°C)	Appearance	Taste	General acceptability
30	5.3±0.62 ^b	5.6±0.82 ^b	5.0±0.64 ^a
35	6.0±0.69 ^a	5.8±0.70 ^a	5.7±0.72 ^a
40	5.9±0.44 ^a	5.8±0.65 ^a	5.6±0.41 ^a
LSD	0.2011	0.1817	0.1251

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at $p \leq 0.05$

Table 7: Mean values of sensory properties of gari as affected by duration of fermentation (h)

Duration of fermentation (h)	Appearance	Taste	General acceptability
12	5.7±0.72 ^c	5.7±0.64 ^c	5.6±0.65 ^{ab}
24	6.3±0.62 ^a	6.2±0.72 ^a	5.5±0.58 ^b
36	6.0±0.51 ^b	6.0±0.67 ^b	5.5±0.59 ^b
48	5.6±0.47 ^c	5.6±0.84 ^c	5.7±0.69 ^a
72	5.2±0.39 ^d	5.0±0.49 ^d	5.1±0.74 ^c
LSD	0.2596	0.2346	0.1616

Means are values of triplicate determination. Means not followed by similar letter of alphabet differed significantly at $p \leq 0.05$

from 5.0 to 20%. Taste as a sensory parameter varies from one locality to another and among consumers for instance, the Ijebu people of South Western Nigeria are known to prefer heavily soured gari (Sanni, 1990). On the other hand, the sample from 5.0% (m/v) preferment was rated best by the panelists in terms of general acceptability (6.1) while the 20.0% (m/v) was scored lowest (4.8). Thus, deliberate addition of spent liquor at 5.0% level might accentuate the sensory properties gari.

Sensory evaluation of gari as affected by temperature of fermentation: Table 6, shows the effects of fermentation temperature on the sensory properties of gari. The gari fermented at controlled temperature of 35°C was rated highest than the rest in terms of appearance. Similarly, the taste of gari increased with increase in temperature. The increasing fermentation temperature may have enhanced optimum production of the desired organic acids and aroma precursors by microorganisms in the fermenting mash.

Moreover, the panelists' adjudged the sample fermented at 35°C as the best. The impact of fermentation time and temperature on quality characteristics and storage of foofoo had been reported by Blanshard *et al.* (1994). Thus, when fermenting temperature is considered as a quality improvement factor in gari production, 35°C would be invariably enhance the sensory properties.

The sensory properties of gari as affected by duration of fermentation: The mean appearance of sample differed significantly ($p < 0.05$) under the condition of study (Table 7).

Duration of fermentation was found to improve the appearance, taste and general acceptability of the resultant gari. However, the panelists rated gari from 48 h as the best in overall acceptance which reinforces the need to ferment cassava mash for a minimum of 2 days (Achinewhu *et al.*, 1998; Achinewhu and Eke, 2002).

CONCLUSION

This study has shown that seeding cassava mash with preferment (spent liquor) improved some of functional properties of the resultant gari such as swelling index and bulk density. When, the spent liquor is limited at 15.0%, the best performance is obtained with regard to swelling index, while the best reduction in residual cyanide (HCN) was obtained from 20.0% preferment addition.

Moreover, limiting spent liquor concentration at 5.0% and fermentation duration at the 48 h and fermentation temperature at 35°C would produce gari with the best physicochemical and sensory characteristics. These processing conditions could be manipulated towards continuous industrial production of gari. However, reduction of cyanide level through pH control at maceration cassava can further enhance food safety.

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