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Evaluation of quality attributes of cassava product (*gari*) produced at varying length of fermentation

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Abstract
Gari is a popular fermented cassava product in Nigeria and other West African countries. Fermentation of cassava mash during *gari* production could have profound effect on the quality attributes of the product. This study therefore investigated the effect of length of fermentation on proximate properties, minerals, antinutritional factors and sensory quality of *gari* produced from bitter (NR8082) and sweet (TM419) cassava varieties. Analysis of *gari* samples produced from TMS419 cassava variety at 0, 24, 48, 72, 96 and 120 hour (h) of fermentation indicated that there was increase in the ash, crude fiber, and crude protein; the contents (mg/100g) increased from 1.65, 0.38, and 2.19 at 0 h to 1.95, 0.55 and 2.41 at 96 h respectively. Antinutritional factors (mg/100g), hydrogen cyanide, tannin, phytate, oxalate and trypsin inhibitor reduced from 275.12, 0.59, 301.21, 46.23 and 7.02 at 0 h to 126.83, 0.41, 64.38, 13.56 and 1.52 at 120 h respectively in the NR8082 cassava *gari* samples. The mineral analysis showed increase in contents with time of fermentation. The *gari* samples produced from TM419 cassava variety recorded similar results as the NR8082 counterparts. Mean scores of sensory attributes of taste, appearance, texture, aroma and general acceptability were higher in *gari* samples obtained at 96 h of fermentation than their other counterparts. It was concluded that length of fermentation between 72 - 96 h yielded good quality *gari* with improved sensory attributes and proximate properties; antinutritional factors also reduced within the period of fermentation in the cassava product.

1. Introduction

Cassava (*Manihot esculenta,* Crantz), also called *manioc* or *yucca*, is one of the most important food crops in the humid tropics, being particularly suited to conditions of low nutrient availability and able to survive drought. It is a widely grown crop in most countries in the tropical regions of Africa, Latin America and Asia; and ranks as one of the main crops in the tropical countries (Calpe et al. 1992). It is the most important food in terms of carbohydrates (Ojo and Akande 2013); and can be processed into various forms such as *gari*, *fufu*, and *tapioca* (Okechukwu and Okoye 2010).

Among the starchy staples, cassava gives a carbohydrate production which is about 40% higher than rice and 25% more than maize, with the result that cassava is the cheapest source of calories for both human nutrition and animal feeding (Nyerhovwo 2004). More than two-third of the total production of cassava is used as food for humans, with lesser amounts being used for animal feed and industrial purposes (Nwokoro et al. 2002). Nigeria alone currently produces over 14 million tonnes annually, representing

about 25% of sub- Saharan Africa's output (Ayodeji 2005).
In cassava, cyanide is an important antinutritional factor which occurs as cyanogenic glucosides, mostly linamarin (>80%) and to a lesser extent lotaustralin (Kimaryo et al. 2000). The cyanogenic glucosides are present in all parts of the plant, with possible exception of the seeds (Vasconcelos et al. 1990). Bitter varieties, which contain higher amounts of cyanogenic glucosides, have to be processed to remove the toxic compounds before consumption, whereas sweet varieties, which have low levels of cyanogenic glucosides, can be eaten raw (Rosling 1990). In spite of this, populations which use cassava as main staple food, mainly grow the bitter varieties due to their higher yields (MMH 1984) as well as their resistance to insects, and therefore rely on processing methods for detoxification. Fermentation enhances detoxification, and may also improve the quality of the food (Ogunsua 1980).

Gari, one of the most popular food products derived from cassava fermentation, is consumed by more than 200 million people across West Africa (Okafor and Ejiofor 1990). It is a lactic acid-fermented product derivable from cassava root which could be processed with or without the addition of palm oil rich in carotenoid. The process of *gari* production from cassava includes fermentation which may last between one to five days, depending on the region where it is being produced. The longer the time of fermentation, the more desirable its sensory characteristics and the more appealing to the customer. However, in a bit to have the product in the shortest time possible, many processors of *gari* do not allow for enough duration of fermentation, thereby compromising quality. The present investigation was therefore aimed at evaluating the effect of length of fermentation on the proximate properties, antinutritional factors and sensory attributes of *gari* produced from sweet (NR8082) and bitter (TM419) cassava varieties, with a view to suggesting to processors the approximate time of fermentation that may be suitable to obtain good quality product.

2. Materials and Methods

2.1. Source of Raw Materials

Fresh root tubers of the two cassava varieties, NR8082 (bitter variety) and TMS419 (sweet variety) used in this study were obtained from National Root Crops Research Institute, Umudike, Abia State, Nigeria. The cassava roots were harvested twelve months after planting; defective portions were separated from the cassava tubers to avoid adverse affect on product quality.

2.2. Processing of Cassava into *gari*

The cassava tubers were processed into *gari* using modified traditional method (Figure 1). Tubers were peeled and grated into mash and then packaged into jute bags in five separate portions. They were subjected to hydraulic press and left to ferment for varying length of time from 24 to 120 h. At 24 hourly intervals, dewatered fermented mash was sieved and *garified* by roasting in deep frying pan (120-140^{o}C) resulting in a product called *gari*. The prodcut was allowed to cool sufficiently (1-2 h) before packaging in polyethylene vinyl chloride bags and labelled. Physico-chemical and sensory analyses were carried out on *gari* samples produced at the varying fermentation periods from 24 to 120 h. The sample produced before fermentation (0 h) was similarly analyzed to serve as baseline control.

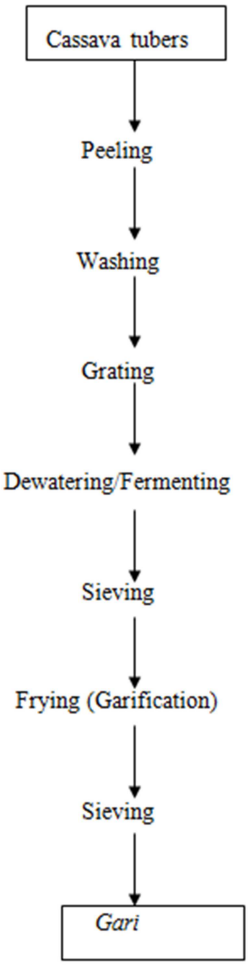

Figure 1. *Flowchart for production of gari*

2.3. Analysis of Proximate Parameters

The proximate parameters, moisture, ash, fat, and protein contents, of *gari* samples were determined using the methods of Association of Official Analytical Chemists (AOAC 2005). Carbohydrate was determined by difference.

2.4. Mineral Analysis

The methods of Saura-Calixto et al. (1983) and Bonire et al. (1990) were used for the determination of mineral contents in the *gari* samples. Potassium and sodium were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer (spectronic20).

Phosphorus was determined by vanado-molybdate colorimetric method. Calcium, magnesium, iron and zinc were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) and compared with absorption of standards of the minerals.

2.5. Determination of Antinutritional Factors

Hydrogen cyanide, tannins, phytates, oxalates and trypsin inhibitor were determined in the *gari* samples by the methods of AOAC (2005).

2.6. Microbial Isolation and Phenotypic Characterization

Malt extract agar and deMann Rogossa Sharpe were used as media for the isolation of yeast/moulds and lactic acid bacteria (LAB) from the fermenting cassava mash using the methods of Olaoye and Onilude (2009). Pure isolates were routinely maintained in broth media containing 20% glycerol at -70°C.

LAB strains were characterised by determination of cell morphology using phase contrast microscopy, Gram staining, catalase test and gas (CO_2) production from glucose using the methods described by Schillinger and Lücke (1987). Sugar fermentations patterns of LAB isolates were determined using the API 50 CHL system (bioMérieux, France) according to the manufacturer's instructions and the identification of LAB strains was performed using the computer program APILAB PLUS (ver. 3.2.2., BioMérieux, France). Yeast/mould strains were characterized by cell morphology. Sugar fermentation patterns were determined using the API 20 AUX system (bioMérieux, France) according to the manufacturer's instructions and the identification of yeast/mould strains was also performed using the computer program.

2.7. Sensory Evaluation

The *gari* samples fermented for varying periods were subjected to sensory evaluation for the attributes of taste, appearance, texture, aroma and general acceptability. A semi trained twenty member panel was used and scores were allocated to the attributes based on a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The data collected were subsequently subjected to statistical analysis to determine possible differences among samples.

2.8. Statistical Analysis

The data obtained, which depended on period of fermentation and cassava variety, were analyzed using the means of three replicates of each sample. Means were separated and analyzed using the *t*-test in data analysis functionality of Microsoft Excel 2010 SP2 (version 14.0.7015.1000) to establish differences. Significant differences among samples were determined at $P < 0.05$.

3. Results and Discussions

Presented in Table 1 is the proximate properties (%) of the *gari* samples produced at different periods of fermentation. The moisture content (MC) varied from 11.22 to 12.89, with sample NR8082 recording the least value at 96 h while sample TMS419 had the highest value at 0 h. The variation could be due to possible fluctuation in frying temperature during *garification*. Moisture plays a very important role in the keeping quality of foods and high moisture can have an adverse effect on their storage stability. Hence, the reduced MC of below 13 recorded in the *gari* samples could be a good indication of their prolonged shelf life (Olaoye et al. 2006; Olaoye and Onilude 2008). Ash contents generally increased with period of fermentation; the highest value of 1.99 was recorded at 120 h for the TMS419 sample and the lowest 1.61 for NR8082 at 0 h. This implies that fermentation had favourable effect on the ash contents following their increase with progression of fermentation. This observation was supported by the findings Adepoju et al. (2010) and Bamidele et al. (2014) who made similar observations in their studies on *gari* production..

The Crude fiber was observed to increase with time of fermentation while the opposite was noticed for crude fat contents of the *gari* samples. The crude fiber contents ranged between 0.38 and 0.65 and the highest value (0.65) was recorded at 96 h for NR8082. Values of Crude fat were within 0.35 and 0.52 during the period of fermentation, the lowest value was recorded for TMS419 *gari* sample at 120 h. The increase in the crude fiber contents of the samples with period of fermentation could be an indication of favourable effect of fermentation. Similar observations were reported by Adepoju et al. (2010) and Owuamanam et al. (2010a) in their findings during *gari* production from fermenting cassava mash fermented for 72 h. The authors recorded crude fibers ranging from 1.6 to 4.0 in *gari* samples after 72 h of fermentation.. In the present report, the decrease in the crude fat contents of the *gari* samples with period of fermentation could be attributed to the metabolic action of microorganisms on fat that may result in production of other products from metabolism (Owuamanam et al. 2010a).

Crude protein contents of the samples increased with period of fermentation up to 96 h. The highest value (2.65) was recorded for the NR8082 sample produced at 96 h of fermentation while the lowest value (2.19) was recorded for the TM419 sample at 0 h. The fermentation process therefore produced significant increase ($P<0.05$) in the protein contents of *gari* samples. Similar observations have been reported by other research workers (Adepoju et al. 2010; Owuamanam et al. 2010a,b).

The mineral (ash), crude fiber and crude fat contents of *gari* obtained from sweet variety of cassava (TM419) were generally higher that their bitter cassava counterparts (NR8082), while the opposite was recorded for crude protein; this was in agreement with the finding of Sarkiyayi and Agar (2010).

The antinutritional factors (mg/100g) of the *gari* samples

are shown in Table 2. The lowest value of 57.37 was recorded for hydrogen cyanides in *gari* produced from TMS419 at 120 h while the highest value (275.12) was obtained for NR8082 at 0 h, indicating that there was reduction with progression of fermentation. Similar observation was noted in the tannin and phytates contents of the *gari* samples, which had respective highest values of 0.59 and 301.21 at 0 h. The values decreased to 0.41 and 64.38 respectively for tannins and phytates at 120 h of fermentation. Oxalates ranged from the lowest value of 8.28 at 120 h and highest 46.23 at 0 h. The lowest value of trypsin inhibitor (0.47) was recorded at 120 h for sample TM419 and the highest (7.02) for NR8082 at 0 h. Results of the antinutritional factors generally showed reduction in values with time of fermentation, confirming the desirable effect of fermentation (Owuamanam et al. 2010b). In addition, application of heat during the *garification* step in *gari* processing may have contributed to reduction in the antinutritional factors (Bamidele et al. 2014). Antinutritional factors are undesirable in foods as they tend to form complexes with certain components and render them unavailable for assimilation in the body. For example, phytates and oxalates usually form insoluble salts with mineral elements such as zinc, calcium and iron to prevent their utilization in the body (Sarkiyayi and Agar 2010). The ability of tannins to form complex with protein, thereby making it nutritionally unavailable, has also been noted (Reed et al. 1985). Hence, the reduction recorded in antinutritional factors in the *gari* samples could be of nutritional advantage. Concentrations of antinutritional factors were generally higher in *gari* samples produced from the bitter cassava variety than the sweet cassava counterparts.

Results of the mineral contents (mg/100g) of *gari* samples showed that 31.41 and 35.22 were recorded for calcium in the *gari* samples produced from NR8082 and TM419 respectively at 0 h (Table 3). These values increased to 44.97 and 52.71 respectively at 120 h. Similar observations were made in the contents of phosphorus, iron, magnesium, sodium and potassium. The process of fermentation may have therefore resulted in the increment of the mineral contents of the *gari* samples obtained from both sweet and bitter varieties, with the former having higher contents than the latter, except for sodium. Therefore, increase in the length of fermentation has desirable effect on the mineral contents of the *gari* samples. In a similar study, Adepoju et al. (2010) reported higher contents of potassium, sodium and magnesium in *gari* samples produced at 72 h than those produced at lower periods of fermentation.

Results of sensory evaluation of the *gari* samples indicate that the mean scores for the attribute of taste were 4.08 and 7.60 at 0 and 120 h respectively (Table 4). The attribute of taste generally recorded increased acceptability in the *gari* samples as fermentation progressed, indicating that fermentation imparted positively on the sensory attribute. A similar trend was recorded in the attribute of appearance which recorded lowest mean score of 4.24 for the TM419 sample at 0 h and highest (7.64) for NR8082 sample at 120 h. Similar results were recorded for the attributes of texture and aroma. The mean scores obtained for the general acceptability indicate that highest score (8.08) was observed at 96 h for the sample produced from sweet cassava variety. Significant differences ($P<0.05$) were recorded in the mean scores of almost all sensory attributes that were evaluated, especially among values obtained between the early stage of fermentation (0-24 h) and the later stage (72-120 h), confirming the significant effect of fermentation.

In term of the microbial analysis, the phenotypic properties (data not shown) of the microorganisms were used in their presumptive identification. Summarily, thirty three (33) strains of lactic acid bacteria (LAB) were identified during the fermentation stage of *gari* production (Figure 2). The LAB consisted of *Lactobacillus plantarum* (15 strains), *L. fermentum* (7), *L. acidophilus* (4), *Leuconostoc plantarum* (5) and *Leu. mesenteroides* (2). Nineteen (19) strains of moulds were also identified, and consisted of *Candida tropicalis* (10), *C. krusei* (5), *Corynebacterium manihot* (2) and *Geotrichum candida* (2). Some of these LAB and moulds have been reported to be associated with the fermentation of cassava mash, especially during *gari* production. For example, Odunfa (1985) reported that *Corynebacterium manihot* was responsible for pH lowering of cassava mash during fermentation of *gari* production while *Geotrichum candida* contributed to production of flavour volatiles, leading to enhanced sensory quality of the product. The genera *Lactobacillus* and *Leuconostoc* were also identified during the fermentation process of *gari* production in studies reported by Odunfa (1985) and Edward et al. (2012); some species within the genera may also contribute to the quality characteristics of the cassava product.

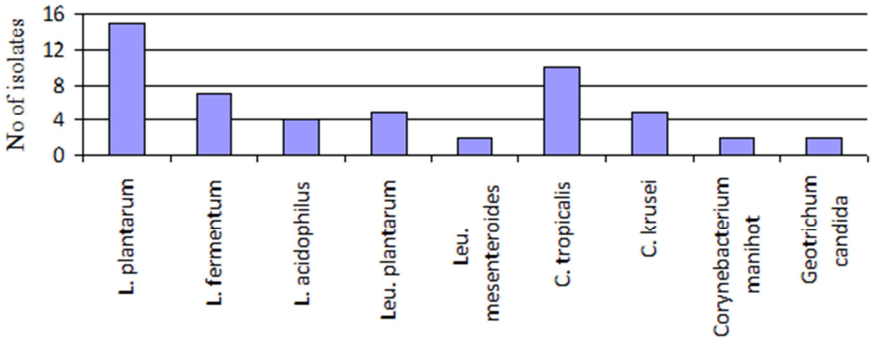

Figure 2. *Microorganisms isolated in the fermentation process of gari production*

In conclusion, fermentation has desirable significant effect on the proximate parameters and mineral contents of *gari*, especially up to the 96 h. Fermentation also reduced the antinutritional factors in the product. From the results of this study, it is suggested that cassava mash for *gari* production be fermented for between 72 and 96 h to obtain enhanced quality of the product.

Table 1. *Proximate properties (%) of gari produced from bitter and sweet cassava varieties*

FP(h)	Samples	Moisture	Dry matter	Ash	Crude Fiber	Crude Fat	Crude protein	Carbohydrate
0	NR8082	12.79^{a}±0.01	87.21^{b}±0.01	1.61^{a}± 0.00	0.42^{c}±0.02	0.48^{b}±0.09	2.39^{e}±0.01	82.03^{e}±0.00
	TMS419	12.89^{a}±0.00	87.12^{b}±0.05	1.65^{a}±0.00	0.38^{cd}±0.04	0.52^{a}±0.05	2.19^{e}±0.00	82.20^{f}±0.05
24	NR8082	12.62a±0.03	87.38^{b}±0.03	1.72^{c}± 0.01	0.46^{c}±0.00	0.45^{c}±0.00	2.46^{d}±0.00	82.33^{d}±0.04
	TMS419	12.67a±0.05	87.34^{b}±0.05	1.68^{b}±0.00	0.44^{a}±0.02	0.49^{b}±0.00	2.24^{d}±0.01	82.39^{e}±0.08
48	NR8082	11.82^{c}±0.03	88.18^{a}±0.03	1.71^{b}± 0.00	0.47^{c}±0.00	0.43^{a}±0.01	2.59^{c}±0.01	82.90^{d}±0.01
	TMS419	12.44^{a}±0.02	87.57^{b}±0.02	1.77^{c}±0.02	0.48^{a}±0.00	0.48^{bc}±0.01	2.31^{c}±0.00	82.59^{d}±0.04
72	NR8082	11.75^{b}±0.01	88.25^{a}±0.01	1.85^{d}± 0.00	0.53^{b}±0.01	0.40^{d}±0.00	2.64^{ab}±0.02	82.96^{bc}±0.05
	TMS419	11.95^{b}±0.14	88.05^{a}±0.01	1.95^{c}±0.00	0.51^{bc}±0.01	0.46^{cd}±0.00	2.34^{b}±0.00	83.16^{c}±0.01
96	NR8082	11.22^{c}±0.03	88.78^{a}±0.003	1.91^{e}±0.00	0.65^{a}±0.00	0.38^{c}±0.00	2.65^{a}±0.00	83.42^{a}±0.04
	TMS419	11.52^{b}±0.00	88.48^{a}±0.00	1.95^{d}±0.01	0.55^{d}±0.00	0.42^{bc}±0.00	2.41^{a}±0.01	83.61^{a}±0.03
120	NR8082	11.58^{b}±0.03	88.42^{a}±0.03	1.93^{d}±0.00	0.62^{b}±0.00	0.43^{a}±0.00	2.61^{bc}±0.01	83.23^{ab}±0.27
	TMS419	11.61^{b}±0.01	88.39^{a}±0.01	1.99^{c}±0.01	0.42^{ab}±0.02	0.35^{d}±0.02	2.35^{b}±0.00	83.47^{b}±0.07

Values are mean scores of three replicates. Mean scores with different superscripts within the same column are significantly different (P< 0.05).
FP, Fermentation period; h, hour; NR8082, Bitter variety of cassava; TMS419, Sweet variety of cassava

Table 2. *Antinutritional factors (mg/100g) of gari produced from bitter and sweet cassava varieties*

FP(h)	Samples	H-Cyanide	Tannins	Phytates	Oxalates	Trypsin inhibitor
0	NR8082	275.12^{a}±2.17	0.59^{a}±0.01	301.21^{a}±4.39	46.23^{a}±0.18	7.02^{a}±0.18
	TMS419	137.17^{e}±0.13	0.37^{b}±0.23	212.36^{b}±0.92	29.15^{b}±1.26	4.04^{b}±0.23
24	NR8082	240.02^{b}±4.32	0.56^{a}±0.07	278.37^{a}±3.26	41.21^{a}±1.28	6.55^{a}±0.92
	TMS419	115.02^{f}±2.19	0.35^{b}±0.03	173.03^{b}±3.25	23.87^{b}±1.25	3.07^{c,b}±1.02
48	NR8082	178.91^{c}±0.82	0.52^{a}±0.03	230.73^{b}±7.58	32.96^{b}±2.13	5.72^{b}±0.61
	TMS419	98.28^{b}±3.34	0.32^{c}±0.08	141.36^{b}±12.27	18.58^{c}±2.17	2.53^{c}±0.91
72	NR8082	143.27^{d}±2.18	0.50^{a}±0.07	125.08^{d}±2.16	25.78^{b}±3.27	3.19^{c}±0.07
	TMS419	82.34^{b}±1.23	0.31^{c}±0.16	101.38^{d}±0.28	15.25^{c}±1.29	1.58^{d}±0.01
96	NR8082	129.47^{c}±0.39	0.43^{b}±0.02	97.37^{d}± 5.46	18.36^{c}±2.17	2.46^{c}±0.08
	TMS419	62.34^{h}±0.88	0.28^{c}±0.00	73.39^{e}± 3.26	11.15^{d,c}±1.28	0.92^{e}±0.01
120	NR8082	126.83^{e}±4.28	0.41^{b}±0.02	64.38^{e}±2.97	13.56^{c}±2.18	1.52^{d}±0.12
	TMS419	57.37^{h}± 5.04	0.24^{d}±0.03	46.38^{f}± 4.35	8.28^{d}±0.08	0.47^{e}±0.06

Values are mean scores of three replicates. Mean scores with different superscripts within the same column are significantly different (P< 0.05).
FP, Fermentation period; h, hour; NR8082, Bitter variety of cassava; TMS419, Sweet variety of cassava

Table 3. *Mineral and vitamin contents (mg/100g) of gari produced from bitter and sweet cassava varieties*

FP(h)	Samples	Ca	P	Fe	Mg	Na	K
0	NR8082	31.41^{d}±0.91	87.4^{d}±2.08	23.0^{f}±2.10	13.72^{d}±1.20	198.02^{e}±1.20	156.28^{h}±0.97
	TMS419	35.22^{e}±1.22	68.7^{f}±0.03	36.1^{d}±3.02	15.27^{c}±2.10	219.21^{c}±2.35	175.27^{e}±1.85
24	NR8082	34.07^{e}±0.22	92.5^{d}±0.92	26.0^{e}±1.20	13.99^{d}±0.27	207.27^{d}±3.20	158.26^{h}±1.26
	TMS419	37.22^{d}±0.32	79.9^{e}±2.74	41.3^{c}±1.92	15.88^{c}±0.08	221.22^{c}±1.29	179.38^{e}±3.78
48	NR8082	38.91^{d}±1.97	112.1^{c}±4.50	35.8^{d}±3.40	14.39^{d}±0.26	209.18^{d}±0.91	164.90^{g}±3.25
	TMS419	42.37^{c}±1.29	86.4^{e}±1.95	52.6^{b},a±1.27	17.02^{a}±0.56	229.19^{b}±2.18	182.37^{d}±2.19
72	NR8082	39.71^{d}±2.02	119.3^{c}±0.97	39.5^{d,c}±2.31	15.02^{c}±2.01	221.12^{c}±5.29	169.29^{f}±5.46
	TMS419	45.34^{c}±1.48	97.4^{d}±3.72	57.2^{b,a}±2.17	17.97^{b},a±1.02	235.90^{a}±0.54	189.74^{c}±2.13
96	NR8082	42.35^{c}±0.61	132.1^{a}±4.08	41.9^{c}±3.09	15.72^{c}±1.25	225.82^{b}±0.93	176.26^{e}±2.15
	TMS419	49.86^{b}±2.44	112.0^{c}±1.24	59.0^{a}±1.20	18.02^{a}±0.19	236.59^{a}±1.28	198.28^{b}±2.18
120	NR8082	44.97^{c}±0.78	129.1^{b}±2.83	43.3^{c}±0.05	16.24^{c}±0.92	225.97^{b}±1.94	177.36^{e}±3.25
	TMS419	52.71^{a}±2.19	109.4^{c}±1.03	62.4^{a}±0.36	19.28^{a}±1.08	235.57^{a}±3.97	213.37^{a}±1.27

Values are mean scores of three replicates. Mean scores with different superscripts within the same column are significantly different (P< 0.05).
FP, Fermentation period; h, hour; NR8082, Bitter variety of cassava; TMS419, Sweet variety of cassava

Table 4. *Sensory evaluation mean scores of gari produced from bitter and sweet cassava varieties*

FP(h)	Variety	Taste	Appearance	Texture	Aroma	General acceptability
0	NR8082	5.00^{d}±1.04	5.12^{d}±0.88	5.12^{d}±0.92	4.16^{d}±1.03	4.60^{d}±1.00
	TMS419	4.08^{d}±1.35	4.24^{d}±1.36	4.16^{c}±1.55	4.76^{d}±1.23	4.60^{d}±1.11
24	NR8082	5.04^{d}±0.78	5.32^{d}±0.80	5.08^{d}±0.76	4.88^{c}±1.09	5.52^{c}±0.82
	TMS419	5.04^{c}±0.97	5.28^{c}±0.73	5.08^{b}±1.19	5.08^{d}±0.81	5.48^{c}±1.08
48	NR8082	5.80^{c}±0.76	6.04^{c}±0.61	5.88^{c}±0.67	5.32^{c}±0.74	6.96^{b}±1.27
	TMS419	5.76^{b}±1.20	6.20^{b}±1.04	5.76^{b}±1.36	5.64^{c}±0.95	5.60^{c}±1.22
72	NR8082	6.36^{b}±0.70	6.80^{b}±0.82	6.76^{b}±0.72	6.52^{b}±0.59	7.12^{b}±0.67
	TMS419	6.84^{a}±1.18	7.20^{a}±0.87	7.24^{a}±0.97	6.92^{b}±0.91	7.32^{b}±0.69
96	NR8082	7.52^{a}±0.96	7.72^{a}±0.79	7.56^{a}±0.92	7.44^{a}±0.59	7.76^{a}±0.78
	TMS419	7.52^{a}±1.38	7.16^{a}±0.94	7.32^{a}±1.25	7.48^{a}±1.00	8.08^{a}±0.86
120	NR8082	7.60^{a}±0.71	7.64^{a}±0.81	7.60^{a}±0.65	7.16^{a}±0.62	7.36^{ab}±1.08
	TMS419	7.12^{a}±0.88	7.04^{a}±0.73	7.16^{a}±0.89	6.72^{b}±0.94	6.72^{c}±0.94

Values are mean scores of three replicates. Mean scores with different superscripts within the same column are significantly different ($P< 0.05$).
FP, Fermentation period; h, hour; NR8082, Bitter variety of cassava; TMS419, Sweet variety of cassava

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