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Evaluation of the quality of melon (*Citrullus colocynthis*) seed meal enriched gari produced from cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) and Irish potato (*Solanum tuberosum*)

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Abstract
The Melon seed meal (MSM 10%) defeated or full fat was used to supplement Cassava, Irish and Sweet potato mash (90%), the fermented mash were roasted to obtain gari, and the un-supplemented served as the control. The various gari were evaluated for proximate composition, mineral profile, functional and sensory properties. Bulk density, swelling index (SI) and water absorption capacity (WAC) of the gari varied significantly ($p<0.05$) from 0.54-0.67g/ml, 1.83-4.20 at 70°C, and 2.26-4.05ml/g respectively. The gari treated with full fat melon seed meal (MSM) had the highest bulk densities numerically although they were not significantly different ($p>0.05$), the supplementation reduced the SI and WAC however Sweet potato gari treated or not had the highest either SI(4.20) or WAC (4.05ml/g). The fat, protein, crude fiber and ash contents of the treated gari were enhanced greater than the control but the moisture and carbohydrate contents decreased with supplementation. Irish potato gari had the greatest nutrient density enhancement especially the full fat treated. The moisture, fat, protein, ash, crude fiber and carbohydrate contents significantly varied from 5.63-10.48%, 0.20-1.23%, 2.88-9.63%, 1.08-2.10%, 1.21-1.92%, and 74.86-84.87% respectively.
Defatting MSM with aqueous ethanol reduced the level of nutrients including mineral elements in the gari treated with defatted MSM, however, with the exception of Zinc, other elements were greater in the untreated gari. Unchecked enzymatic browning marred the appearance of Irish potato gari which in turn down-graded other sensory attributes despite higher nutritional value while cassava and sweet potato gari treated or not were well appreciated by test panelists. Commercialization of full fat MSM treated cassava and sweet potato gari is advocated for better nutrition and wellness of consumers.

Keywords: roots/tubers, *Citrullus colocynthis*, gari, supplementation, fermentation, roasting

1. Introduction
Gari is a free flowing granulated cassava-based convenient food obtained by roasting a lactic acid- fermented cassava mash; it is a popular food for many urban dwellers of Nigeria and some West African countries because of its convenience and storage stability. Gari is eaten as *eba* (hot water gari stiff dough) with traditional soups or soaked in water or liquid milk, sweetened and consumed with other food items in order to enhance its nutritive value and taste because a general knowledge exist that roots in general or their products are deficient in protein and fat. According to USDA [1], the carbohydrate, protein, and fat contents of cassava, sweet potato and Irish potato are respectively 38.08%, 1.36%, 1.8%; 20.12%, 1.6%, 3.0%; 17.40%, 2.05% and 2.1% (fresh weight basis). Consumption of tuber crop-based meal is usually accompanied with protein-rich food items such as meat, fish, grain legume added to vegetable soups or sauces. Cassava (*Manihot esculenta*), sweet potato *(Ipomoea batatas* L.) and Irish potato (*Solanum tuberosum*) are all natives of the pre-Columbian America but now are cultivated in other regions of the world. Cassava is a perennial woody shrub of the Euphorbiaceae family grown principally for its starch-filled tuberous roots; it is reported to be the major source of carbohydrate for more than 500 million people in tropical Africa, South America and Asia; providing 37%, 12% and 7% of dietary energy in these regions respectively [2, 3]. Nigeria is a leading producer of cassava and sweet potato in Africa and they are grown exclusively for human foods. Sweet potato thrives in tropical and warn temperate regions of the world. It is loaded with carotenoids, dietary fibre, minerals, vitamins and bioactive compounds such as phenolic acids and anthocyanins [4].
Irish potato on the hand is a temperate crop but thrives well in high attitude places, and in Nigeria such places include Jos, Mambila and Obudu plateau and also cultivated in different parts of northern Nigeria through irrigation farming. Jos South, central Nigeria accounts for 25% of total Irish potato production in Nigeria [5].
Melon (*Citrullus colocynthis* Syn. lanatus) or traditionally called *egusi* is an annual, monoecious, herb of the family Cucurbitaceae with wide adaptation therefore grown extensively in Nigeria as an intercrop with yam or cassava and often regarded as the parent of a popular fruit called water melon. Its oil and protein contents vary respectively 46-53% and 23.4- 35%; contain sufficient vitamins, minerals and beneficial phytochemicals [6, 7, 8, 9]; its oil consists of 57.4% polyunsaturated and 14.5% monounsaturated fatty acids [7]; the seed protein contain high amounts of arginine, tryptophan and sulphur amino acids. Egusi seeds either boiled or roasted are popular snacks in south eastern Nigeria, in addition, the shelled ground seeds are popular soup thickener and when fermented an aroma-filled soup condiment called *Ogiri* is formed, popular among the Igbo ethnic group of Nigeria.
Leaching or loss of nutrients in a nutrient-deficient staple root

during fermentation/dewatering of the mash is a serious drawback in gari manufacture worsening the incidence of under -nutrition for gari consumers. Chronic denial of food energy and dietary nitrogen substrates are the procurers of protein energy malnutrition [10]. Root crops are the target of biofortification because of their wide geographical distribution and are the chief staples in parts of world where malnutrition is endemic. Enhancement of the quality of existing traditional foods or fabrication of new ones with oil seed extracts or their meal has been widely studied mostly with soybean seeds [11, 12, 13], they had successfully enriched gari with seed meal from soybean or bambara groundnut. High postharvest losses associated with roots and tubers are due to high inherent moisture content (60-90%), mishandling and the associated physical injuries that follow exacerbate microbial deterioration and negative biochemical changes leading to quality and quantity losses. Fermentation of the tuberous mash coupled with thermal dehydration is a technology utilized for cassava gari production, which can be equally extended to other root/tubers in order to reduce postharvest losses; further more supplementation with legume seed meal yields nutritive, shelf-stable products that go a long way to mitigate food insecurity occasioned by population surge in most developing countries such as Nigeria. With this background information, the thrust of this study was to transform cassava, sweet and Irish potatoes tuber crops into gari, enhance the nutrient density of the same with melon seed meal, and thereafter evaluate the proximate composition, mineral contents, functional and sensory properties of the various gari.

2. Materials and Methods

2.1 Collection of Raw Materials

Citrullus colocynthis shelled seeds, yellow-skinned sweet potatoes (*Ipomoea batatas*), Irish potatoes (*Solanum tuberosum*) were purchased at Gamboru Vegetable market, Maiduguri northeastern Nigeria and were taken to the Food Process Laboratory, Department of Food Science & Technology, University of Maiduguri. Ethanol (80%) and citric acid were obtained from a local chemical store and were of analytical grade.

2.2 Preparation of Raw Materials for Gari Production

Twenty kilogram (15kg) each, of fresh cassava (C), sweet potato (sP) and Irish potato (iP) were washed to remove adhering earth, peeled, sliced into small bits (<5mm thick) into three separate bowels each containing warm 2% citric acid solution, after 5 min, the slices were removed and rinsed with tap water. They were separately ground, and the resulting mash from each tuber crop was portioned into three. Shelled melon seeds (M) were sorted, washed, sun dried and ground, then portioned into two, one portion was defatted using 80% ethanol (1:3w/v) vigorously mixed, the floated oil decanted and the wet mash was wrapped in a muslin cloth, squeezed to remove residual ethanol, and the defatted meal was placed in the hot air-oven at 100·C 1 h to dry. The full fat or defatted melon seed meal (10%) was added to the mashes on a replacement basis as presented in Table1and the process flow chart shown in Figure 1

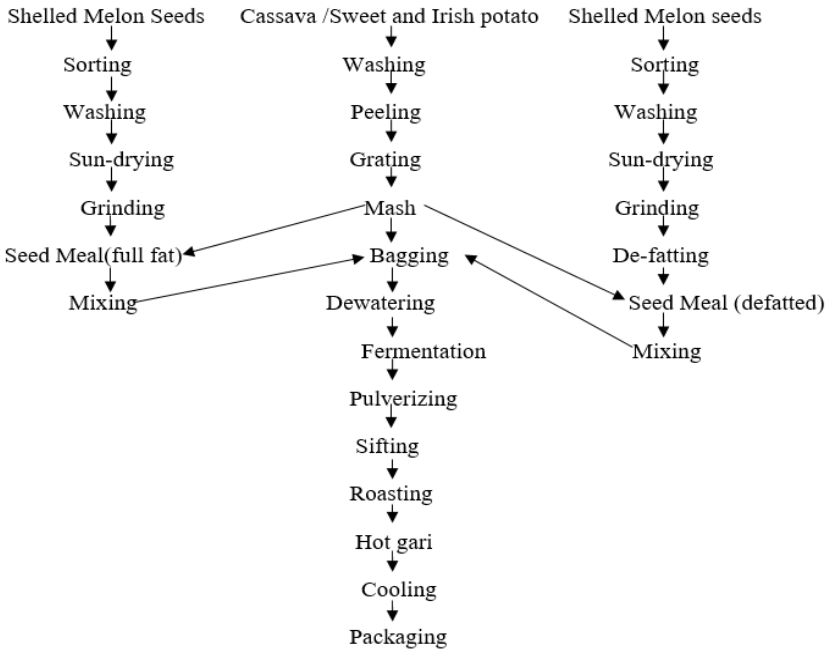

Fig 1: Flow diagram showing the production of melon seed meal supplemented gari from cassava, sweet and Irish potatoes.

Table 1: Gari formulations with Cassava(C), Irish (iP) and Sweet potatoes (sP) supplemented with melon seed meal (MSM)

Supplementation	Cassava-Melon Seed Meal Mash(C)	Sweetpotato-Melon Seed Meal Mash (sP)	Irishpotato-Melon Seed Meal Mash (iP)
None	C100:00	sP100:00	iP100:00
Full fat melon seed meal(F)	CF90:10	sPF90:10	iPF90:10
Defatted melon Seed meal(D)	CD 90:10	sPD 90:10	iPD90:10

A total of nine mashes were obtained, and each thoroughly mixed in a Kenwood blender and bagged in a cotton sack, then dewatered by subjecting sack to manual pressure, then left to ferment for 72 h in an ambient condition.
At the end, each dewatered fermented mash was manually pulverized, sifted using a local cane sieve, then roasted on a shallow iron pan over a smoldering fire, continuously stirred until a free flowing mass was obtained. The hot gari was spread on a tray to cool and finally packaged in separate polyethylene bags.

2.3 Physicochemical Analysis

2.3.1 Proximate composition

Proximate composition of the different gari were determined using the established procedures of the AOAC [14]. Moisture contents were determined using direct oven drying method, crude fat contents by extraction of a weighed sample in a Soxhlet extractor using petroleum ether for 3 h, crude protein (%N×6.25) determined using micro Kjeldahl method and total ash by incinerating a weighed sample in a muffle furnace at 550·C for 5 h, crude fibre was determined using alternate digestion of a fat free dried sample with dilute H_2SO_4 and NaOH solutions followed by oven drying and lastly incineration in a muffle furnace. Carbohydrate contents were obtained by 'difference'. Food energy was obtained by multiplying gross nutrients with Atwater conversion factors.

2.3.2 Analysis of mineral elements

Mineral elements in the samples were determined according to the approved procedures of AOAC [14]. Five grams (5g) of each sample was ashed in a muffle furnace at 550C for 6h, the resulting ash was dissolved in 20ml dilute hydrochloric acid, the mixture was filtered and transferred into 100ml volumetric flask, the filtrate was made up to volume with deionised water. The concentrations (mg/100g) of Zinc, Iron, Calcium, Magnesium in the filtrate were determined using atomic absorption spectrophotometer (SMART Spectro 2000 LaMotte) using pre calibrated tests for the LaMotte reagent systems. In each case the aliquot of the filtrate was scanned blank and later scanned again after the required reagents were added, the displayed result was read. Phosphorus was determined colorimetrically using vanadomolybdate, absorbance was taken at 400nm using Spectronic 20(SP20, Baucsh and Lomb).

2.3.3 Functional properties of the various gari

Bulk density of each gari was determined by the method described by Onwuka [15]; the water absorption capacity by the method of Beuchat [16] and the swelling power at 30C and 70C by the method of Okaka and Potter [17].

2.3.4 Sensory evaluation of the raw gari and eba

A panel of fifteen (15) staff and students (6 males and 9 females) of the Department of Food Science and Technology, University of Maiduguri evaluated the sensory attributes of the gari and eba (hot water gari dough) on the basis of 9-point Hedonic scale where 9 represents extremely liked, 5 neither liked nor disliked, 1 represents extremely disliked. Coded samples of gari or eba were presented to the panelists on disposable plates, the attributes assessed were appearance, taste (degree of sourness), texture (extent of graininess), aroma and the mean scores of each attribute was reported as the overall acceptability score. Table water was provided to the panelists for mouth gaggling in between tests.

2.4 Statistical analysis

Analytical procedures were carried out in triplicates from which mean values were calculated and reported. Data obtained were subjected to one-way analysis of variance using SPSS version 16 (SPSS Inc., Chicago, IL). Significance was accepted at 5% level of probability ($p<0.05$).

3. Results and Discussion

3.1 Functional properties of the various gari

Bulk density, water absorption capacity (WAC) and swelling index (SI) of the various gari varied significantly ($P<0.05$) as follows: 0.54 – 0.67g/ml, 2.26 – 4.05ml/g,1.05 – 3.27ml/g 30°C, 1.86-4.19ml/g 70˚C respectively. The variations in the bulk densities of the gari were not significant although the numerical values of the full fat treated gari were higher (0.63 – 0.67g/ml). Among the untreated, sweet potato gari had the highest swelling index (2.97 at 30˚C and 4.20 at 70˚C) and those of Irish potato gari the least. The untreated gari had greater swelling index indicating the treatment or the fat presence inhibited the swelling of starch granules in aqueous medium. Surprisingly, gari with defatted melon seed meal (MSM) had the least swelling indices slightly lesser than the values recorded for full fat melon seed meal. The defatting melon seed meal with aqueous ethanol followed by oven drying (70˚C) might be responsible for reduced swelling index and water absorption capacity of gari treated with defatted melon seed meal. However, supplementation with melon seed meal reduced the SI and WAC of the supplemented gari. Bankole *et al*. [13] similarly observed reduction of SI and WAC. As for WAC, the untreated gari had the highest, WAC of untreated cassava (4.05ml/g) and sweet potato (4.00ml/g) gari were significantly not different ($P<0.05$) but greater than WAC of Irish potato gari (3.75ml/g) full fat and 3.38ml/g defatted. Bamidele *et al*. [18] recorded 120 – 150 for WAC of cassava – cocoyam gari and Owuamanam *et al*. [19] reported a range of 1.11 to 1.44ml/g for gari produced using a preferment and a bulk density of 0.6160 – 0.5977g/ml. WAC of a material depends on the availability of polar polymeric units such as protein and carbohydrate, and like swelling index (SI), it is inhibited by the presence of non- polar substances such as fat. A good gari should swell thrice its dry volume and a bulk density of 0.55 – 0.82g/ml. [20]. Sanni *et al*. [21] reported SI of 3.29 – 3.69 of differently roasted gari. Bulk density of a powdered material is a reflection of its particle size, higher particle size aids dispersion in water, however overly sized particle will create packing, handling and storage problems in addition to poor textural attribute of the eba.

Table 2: Functional properties of melon seed supplemented gari from three different tubers and the control

Gari	Bulk density (g/ml)	Swelling Index		WAC (ml/g)
		30°C	70°C	
C100:00	0.55^{ab}	2.29^{b}	2.92^{b}	4.05^{a}
iP100:00	0.58^{ab}	1.95^{ab}	2.51^{c}	3.53^{c}
sP100:00	0.63^{a}	2.97^{ab}	4.20^{a}	4.00^{a}
CF90:10	0.63^{a}	1.35^{d}	2.00^{d}	2.45^{cd}
iPF90:10	0.67^{a}	1.76^{c}	2.92^{b}	2.88^{c}
sPF90:10	0.67^{a}	2.98^{ab}	4.19^{a}	3.75^{b}
CD90:10	0.54^{ab}	1.05^{e}	1.83^{e}	2.56^{c}
iPD90:10	0.58^{ab}	1.57^{c}	1.86^{e}	2.26^{d}
sPD90:10	0.60^{ab}	3.27^{a}	3.92^{ab}	3.38^{bc}

Results are mean of triplicate determination; means with same superscripts in the same column are not significantly ($p>0.05$). C=cassava, iP=Irish potato, sP=Sweet potato, F=Full Fat Melon Seed Meal (MSM), D=Defatted MSM

3.2 Proximate composition of the various gari

Moisture contents of the gari varied significantly ($p<0.05$) from the highest value (10.48%) in sP100:0 gari to the least (5.87%) observed in sPF90:10 gari (Table 3). Generally, the moisture contents of the various gari were low, indicative of high storage potential and greater dry matter. Untreated gari had greater moisture level than the treated especially the sweet potato gari and gari with full fat MSM had the least moisture level. Komolafe and Arawande [22] reported a range of 11.78-11.81% of gari produced from three cultivars of cassava, Bamidele *et al*. [18] reported a moisture range of 7.28-7.78% for cassava-cocoyam gari, a range closer to the values observed here. Moisture content of gari is dependent on extent of roasting, particle size distribution and fermentation time. Untreated gari (Ca100:0, iP100:0 and sP100:0) had highest moisture contents but gari with full fat melon seed meal (MSM) had the least possibly because of the higher presence of fat: 6.23% CF, 5.55% iPF and 5.68% sPF. Fat contents of the gari varied significantly from 0.20% to 6.23% and the untreated garis had the least fat contents that were not significantly different ($p>0.05$) from each other. The fat, protein, ash, and crude fiber contents of the treated gari were enhanced due to MSM supplementation at the expense of moisture and carbohydrate contents. Rojas *et al*. [23] reported the proximate composition of six varieties of cassava as: lipid 0.58-1.4%, protein 1.46-2.76%, ash 1.46-2.71%, carbohydrate 71.6-84.0%; on the other hand Alam *et al*. [24] reported the following proximate values for nine orange-fleshed sweet potato varieties grown in Bangladesh: moisture 70.95-72.44%, protein 1.91-5.83%, fat 0.17-0.63%, crude fiber 0.30-0.54%,ash 1.17-1.31% and carbohydrate 21.10-24.50%. These reported values proved that nutrient density enhancement in the treated garis were the result of MSM supplementation. Jacob *et al*. [9] reported that melon seed, an oil seed has high level of protein (30.63%), fat (49.08%), ash (2.70%), crude fibre (6.00%) and carbohydrate (4.52%).The gari treated with full fat MSM had greater fat contents therefore greater food energy which varied significantly from 351.43-394.0 kcal/100g. Most commercial gari of premium of quality are produced with the addition of red oil but fat from MSM is better with 57.40% polyunsaturated fatty acids [25].

Protein profile of the gari indicated enhancement of protein contents of the gari since untreated samples had least amounts of protein (C100:0 2.88%, iP100:0 4.63%, sPi00:0 3.38%) and irish potato gari had the highest amount of protein whether treated or not (iP100:0 4.63, iPF 9.63% and iPD 9.13) and the next in that order were cassava gari and lastly sweet potato gari. The values obtained significantly varied from 2.88% (C100:0) to 9.63% (iPF90:0). Karim *et al*. [26] reported that cassava-sweet potato gari contains 1.43-4.27% protein, 1.93-1.98% crude fiber. Aiyelegun *et al*. [27] recorded ash and crude fiber contents of gari produced in the southern Nigeria as 0.48-2.59% and 0.27-5.14% respectively. Komolafe and Arawande [21] reported gari from three cultivars contain 0.4-1.10% fat, 1.65-2.25% crude fibre, 1.04-1.40% protein, ash; Bamidele *et al*. [18] recorded the following values for cassava-cocoyam gari: protein1.57-4.43, crude fiber, 1.53-2.19%, ash 1.89-2.50%. Gari is a staple food for over 200 million people across West Africa. It is recognized that dependence on a single starchy food for energy and nitrogen substrates is responsible for malnutrition in developing countries of the world and malnutrition is an underlying factor in the etiology of many infective and non-infective disease conditions. Protein requirement of 0.66/kg/day is stipulated for healthy adults (FAO/WHO/UNU [28]. Crude fiber contents of the gari varied from 1.21-1.92% and the untreated samples had the least crude fiber contents and gari with full fat MSM the highest. Crude fiber enhancement is beneficial to gari consumers since dietary fiber is believed to reduce the incidence of colonic cancer, diabetes, heart and certain digestive diseases (Alam *et al*. [23]. Ash represents the chemical elements present in a material, the significant event was the ash contents of garis with defatted seed meal were the highest, and the untreated gari the least. Ash contents significantly varied from 1.08% in C100.0 to 2.1% in iPD, sightly greater than the ash contents of gari (1.61 - 1.99%) produced applying varying length of fermentation reported by Olaoye *et al*. [29]. Rojas *et al*. [22] found that dried pulp of six varieties of cassava contained ash that ranged from 1.46-2.71.It is to be noted that dewatering of the mash usually leads to the leaching of useful substances such as amino acids, sugars, peptides, vitamins such as vitamin C as well as unwanted cyanogenic glucosides further diminishing the nutritional value of nutrient-deficient staple.

Table 3: Proximate composition (%) of gari produced from Cassava, Irish and Sweet potatoes supplemented with melon seed meal.

Sample Code	Moisture	Ash	Fat	Fibre	Protein	C/hydrate	Energy(kcal)
C100:0	9.45^{b}	1.08^{e}	0.53^{c}	1.21^{e}	2.88^{f}	84.87^{a}	355.7^{b}
iP100:0	8.52^{c}	1.30^{d}	0.20^{d}	1.41^{d}	4.63^{d}	83.96^{ab}	356.16^{b}
sP100:0	10.48^{a}	1.15^{e}	0.23^{d}	1.25^{e}	3.38^{e}	83.96^{ab}	351.43^{b}
CF90:10	5.63^{f}	1.38^{d}	6.23^{a}	1.51^{c}	7.13^{b}	77.14^{d}	393.15^{a}
iPF90:10	6.78^{e}	1.53^{b}	5.55^{b}	1.66^{b}	9.63^{a}	74.86^{e}	387.91^{a}
sPF90:10	5.87^{f}	1.30^{d}	5.68^{b}	1.45^{d}	5.88^{c}	79.84^{c}	394.00^{a}
CD90:10	7.64^{d}	1.48^{c}	3..38^{c}	1.63^{b}	6.63^{bc}	79.26^{c}	373.86^{a}
iPD90:10	7.40^{d}	2.10^{a}	3.13^{c}	1.92^{a}	9.13^{ab}	76.33^{d}	372.53^{a}
sPD90:10	8.54^{c}	1.38^{d}	3.35^{c}	1.50^{c}	5.·63^{c}	79.62^{c}	371.15^{a}

Results are mean of triplicate determination; means with same superscripts in the same column are not significantly (p>0.05).C=cassava, iP=Irish potato, sP=Sweet potato, F=Full Fat Melon Seed Meal (MSM), D=Defatted MSM

3.3 Mineral profile of the various gari

There were significant variation (p<0.05) in the mineral contents (mg/100g) of the various gari. Zinc, Magnesium, Phosphorus, Iron Calcium contents varied respectively: 0.31-0.78, 8.04-16.87, 8. 15-15.65, 4.36-17.01, and 3.20-9.40. Least concentration of elements was observed in all the gari treated with defated melon seed meal (MSM) with the sweet potato gari badly affected. With the exception of Zinc, other minerals were greater in the untreated gari especially the irish potato gari where the highest Mg (16.87mg/100g), phosphorus (15.65g/100g) and calcium (9.40g/100g) were observed. Highest levels of iron were found in untreated cassava and sweet potato respectively 16.30 and 17.01g/100g respectively. The highest levels of calcium were in the untreated gari and were not significantly different from each other (8.40-9.60g/100g).Full fat MSM treated gari had greater concentration of minerals than gari treated with defated MSM. Defatting of the MSM with aqueous ethanol (80%) did decrease the concentration of the nutrients including the minerals. Equally, leaching as a result of dewatering process generally affected the concentration of the nutrients. Adepoju *et al*. [30] similarly observed the effect of leaching in gari production. Higher levels of minerals in the untreated gari indicate that the tubers contained more of these minerals than the MSM or the 10% level of supplementation had insignificant effect. Rojas *et al*. [23] studied the elemental composition of six varieties of cassava and reported as follows: Ca, 0.340-440mg/kg, Fe, 0.68-7.8mg/kg, K, 458-1161mg/100g, among others. Olaoye *et al*. [29] reported the following for gari obtained using varying length of fermentation: Ca, 31-52.7; P, 68.7-129.1; Fe, 23-62.4; Mg, 13.72-19.28; Na, 198.02-235.57; K, 156.28-13.37; (mg/100g), far greater than values obtained in this study. Bamidele *et al*. [18] reported an increase in the mineral contents of cassava-cocoyam gari with increase in cocoyam addition; on the other hand Ajifolokun and Adeniran [31] reported that mineral contents of breadfruit-cassava gari decreased with increase in the level of breadfruit supplementation. The ratios of Ca-to-P in the various gari were less than the ideal ratio of 1, untreated gari had better ratio than the treated. Ca-to-P varied from0.31 to 0.64. The level of mineral consumption according to Vaskonem [32] partially contributes to serum lipid profile. McArdle *et al*. [33] itemized the function of mineral elements in human system as follows; bone & teeth formation, regulation and maintenance of metabolism, regulation of muscles, nerve and heart activities and maintenance of the acid- base balance of the internal fluids. Low Ca-to-P less than1and Na-to-K greater than 1 has negative implication on lipid metabolism. Significant positive correlation between Ca-to-P ratio and serum high density lipoprotein cholesterol has been established [34]. The wide variation on the reported mineral contents of cassava or their products could be attributed to varietal differences, processing methods, geographical and climatic factors.

Table 4: Mineral Profile (mg/100) of the control and treated melon seed meal gari

Sample Code	Zn	Mg	P	Fe	Ca	Ca/P
C100:00	0.50^{bc}	12.33^{cd}	13.40^{b}	16.30^{ab}	8.60^{ab}	0.64
iP100:00	0.55^{b}	16.87^{a}	15.65^{a}	12.95^{b}	9.40^{a}	0.60
sP100:00	0.52^{b}	14.03^{b}	13.95^{b}	17.01^{a}	8.91^{ab}	0.64
CF90:10	0.78^{a}	9.48^{e}	10.32^{d}	5.24^{d}	4.25^{bc}	0.41
iPF90:10	0.81^{a}	13.40^{c}	11.30^{cd}	5.81^{c}	4.56^{b}	0.40
sPF90:10	0.70^{ab}	10.09^{d}	9.75^{e}	4.94^{e}	3.06^{d}	0.31
CD90:10	0.44^{c}	8.61^{d}	8.72^{f}	4.68^{ef}	3.35^{c}	0.38
iPD90:10	0.53^{b}	9.52^{e}	11.90^{c}	5.14^{d}	4.24^{bc}	0.49
sPD90:10	0.31^{d}	8.04^{f}	8.15^{fg}	4.36^{f}	3.20^{d}	0.39

Results are mean of triplicate determination; means with same superscripts in the same column are not significantly (p>0.05).C=cassava, iP=Irish potato, sP=Sweet potato, F=Full Fat Melon Seed Meal (MSM), D=Defatted MSM.

3.4 Sensory evaluation of the various gari

There were significant variation (P<0.05) in the sensory attributes of the various gari and eba as shown in Table 5. Cassava gari/eba treated or not had better scores and in some cases not significantly different from those of Sweet Potato gari/eba. The general picture was gari/eba that contained full fat were well appreciated by the panelists better than the gari/eba treated with defatted MSM. Appearance, texture, taste, aroma and overall acceptability scores of the gari varied significantly from 5.12-8.61, 6.11-8.50, 7.03-8.47, 6.80-8.11 and 6.42-8.27 respectively. The eba prepared from these various gari had sensory scores that follow the same trend observed for the gari. Appearance of Irish potato gari treated or not were not appreciated by the test panelists because of the grayish-black color due to enzymatic browning which was not retarded by hot water/citric acid treatment, and appearance of cassava and sweet potato gari/eba were significantly (P>0.05) the same. Cassava gari/eba had uniform granulation therefore had better texture scores than sweet potato and Irish potato garri/eba the later had very coarse granulation.

Supplementation of gari with defatted or full fat MSM (10%) did not negatively influenced the texture, taste or the aroma of the various gari/eba. Untreated gari had the best taste (8.47-8.51) scores; those which were overly sour received lower scores. Fermentation of the mash by lactic-acid bacteria makes well processed gari sour with minimum fermentation time of 72 h; the degree of sourness depends on the availability of fermentable substrates. Aroma scores of the various gari/eba were high; those of cassava and sweet potato were adjudged the best. The duo had the best overall acceptability score. Agbara *et al*. [35] reported that sweet potatoes compete squarely with cassava for gari production as a root crop for gari production. Now cassava roots are facing competing needs as human food, animal feed and industrial raw material, therefore sweet potato may serve as an alternative raw material for gari production. Appearance of Irish potato gari/eba especially the untreated downgraded other sensory attributes; addition of full fat MSM (10%) slightly improved the appearance scores better than the use of defatted MSM.

Table 5: Sensory attributes and acceptability scores of melon seed meal enrich gari and eba

Sample	Appearance Gari (eba)	Texture (Graniness) Gari (eba)	Taste (sourness) Gari (eba)	Aroma Gari eba)	Overall acceptability Gari (eba)
CF100:00	8.21^{ab} (8.26^{ab})	8.35 (8.40)	8.47^{a} (8.51^{a})	8.11^{a} 8.00^{a})	8.27^{a} (8.29^{a})
CF90:10	8.56^{a} (8.51^{a})	8.48 (8.27)	8.00^{b} (8.31^{a})	7.60^{ab} (7.81^{a})	8.16 (8.23^{a}
CD90:10	8.52^{a} (8.43^{a})	8.56 (7.69)	7.60^{c} (7.85^{b})	7.40^{ab} (7.77^{a})	8.02^{ab} (7.94^{a})
IP100:00	5.18^{d} (5.12^{d})	6.11 (5.74)	7.19^{cd} (6.82^{c})	7.21^{ab} (7.13^{bc})	6.42^{d} (6.20^{b})
IPF90:10	6.07^{c} (5.81^{c})	7.33 (5.8^{b})	7.25^{cd} (6.68^{c})	7.49^{ab} (7.18^{bc})	7.04^{bc} (6.38^{b})
IPD90:10	6.34^{c} (6.10^{c})	7.28 (6.10)	7.03^{d} (6.67^{c})	6.80^{b} (7.00^{bc})	6.86^{c} (6.47^{b})
SP100:00	8.10^{ab} (8.16^{ab})	8.02 (7.83)	8.18^{b} (8.21^{ab})	7.09^{b} (7.57^{a})	8.05^{ab} (7.94^{a})
SPF90:10	8.61^{a}(8.53^{a})	8.41 (7.32)	7.88^{c} (8.13^{ab})	7.54^{ab} (7.68^{a})	8.11^{ab} (7.92^{a})
SPD90:10	7.34^{b} (7.74^{b})	7.37 (7.15)	7.21^{cd} (7.85^{b})	7.45^{ab} (7.47^{b})	7.34^{b} (7.55^{ab})

Results are mean of triplicate determination; means with same superscripts in the same column are not significantly ($p>0.05$).C=cassava, iP=Irish potato, sP=Sweet potato, F=Full Fat Melon Seed Meal (MSM), D=Defatted MSM

4. Conclusion

Gari is a convenient starchy food traditionally obtained from fermented and roasted cassava mash. Nutritional considerations and rising food insecurity in developing countries have motivated the need for gari analogues. Supplementation of gari from cassava, irish and sweet potato with melon seed meal (MSM) enhanced their nutrient density especially those supplemented with full fat MSM without negatively affecting well-cherished sensory attributes of the gari. Swelling index and water absorption capacity of the treated gari decreased, more in the gari treated with defatted MSM. Enzymatic browning affected the appearance of irish potato gari especially the untreated which in turn affected other sensory attributes however irish potato had the best nutrient profile. Cassava and sweet potato gari treated or not were almost similar in terms of nutritional profile, functional and sensory properties. Commercial production of full fat MSM supplemented gari from cassava and sweet potato is advocated for enhanced nutritional and health benefits for consumers.

5. References

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