Quality evaluation of Ready-To-Eat *Garri* made from Cassava mash and mango fruit mesocarp blends

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ABSTRACT

Garri is a popular, easy to prepare, storable and low cost staple food made from cassava roots, but lacks the right balance of nutrients. The aim of this study was to evaluate the effect of incorporating mango fruit mesocarp flour as a supplement on the functional, physicochemical and sensory properties of *garri*. Four blend ratios and codes of 100:0 ($C_{100}M_0G$), 90:10 ($C_{90}M_{10}G$), 80:20 ($C_{80}M_{20}G$) and 70:30 ($C_{70}M_{30}G$) were developed for cassava mash and mango fruit mesocarp flour respectively. The proximate composition, vitamin and elemental composition, functional properties and sensory attributes of the samples were analysed using standard methods. Results from this study revealed that increase in mango fruit mesocarp flour supplementation in the *garri* increased the protein (1.01 to 1.42%), fat (negligible increase), ash (0.47 to 1.28%), carbohydrate (82.99 to 87.15%), Vitamin A (3.00 to 160.66 µg/100g), Vitamin C (10.23 to 33.34 mg/100g), calcium (0.43 to 1.04%), potassium (0.07 to 0.28%), sodium (0.05 to 0.22%) contents as well as sensory attributes whose values ranged from 5.7 to 7.9 on a 9 point hedonic scale; while decreasing the moisture (12.60 to 7.85%) and crude fibre (2.93 to 2.30%) contents in addition to the bulk density (0.66 to 0.51 g/ml), water absorption capacity (2.11 to 1.30 g/g) and swelling capacity (1.09 to 0.78 g/g). Therefore, adding mango fruit mesocarp flour as supplement has the ability to enhance the macro- and micro-nutrient content, functional properties and sensory characteristics of *garri*. Sensory evaluation revealed that $C_{70}M_{30}G$ was the most preferred blend formulation.

Keywords: Garri; cassava mash; mango fruit mesocarp flour; micronutrients; sensory characteristics; proximate composition; functional properties

1. INTRODUCTION

Malnutrition remains a challenge in developing countries especially in Sub-Saharan Africa. Nevertheless, this has strengthened the resolve of relevant stakeholders to improve food processing, enrichment and fortification initiatives, which will ultimately boost the nutritive quality of staple foods. Staple foods are those foods eaten regularly, and in such quantities that they constitute the dominant part of the diet and supply a major proportion of energy and nutrient needs [1]. *Garri* is a popular staple food processed from cassava. It is a creamy-white, granular flour with a slightly fermented flavour and a slightly sour taste made from fermented, gelatinized fresh cassava roots [2]. It demands attention considering its position in the dietary regime of a developing country like Nigeria [3]. *Garri* is a convenient product because it is stored and marketed in a ready-to-eat form [4].It is eaten as eba (hot water *garri* stiff dough) with traditional soups or soaked in water or liquid milk, sweetened and consumed with other food items [5].
Nigeria is reported to be the highest producer (about 34 million tons) of cassava in the world [6]. Nutritionally, cassava contains 62% water, 35% carbohydrate, 1.0% protein, 0.3% fat and 1.0% minerals [6]. Some of these nutrients become depleted during processing due to long exposure to thermal heat. Apart from high temperature associated with *garri* production, 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 [5].

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Mango (*Mangifera indica*) is the king among tropical fruits and is greatly relished for its succulence, exotic flavour and delicious taste in most countries of the world [7]. The fruit contains amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins, vitamins (A and C) and dietary fiber [8]. Benue State is the largest mango producer in Nigeria, while Nigeria ranks 8th in the world with total production of 730,000 metric tons [9, 10]. The shelf life of mango fruits poses a lot of concern to the rural and urban dwellers, since there is no efficient storage facility that exists. In other words, due to higher moisture content (85%); mango has very poor keeping quality and cannot withstand any adverse climatic conditions during storage [11]. As a result, large amount of mango produced in Nigeria, especially Benue State in North Central Nigeria suffer from huge postharvest losses.

Previous studies have reported *garri* supplemention using locally available plant materials [2, 5, 12-16]. Aside those reported so far, there are several other potential possibilities for the formulation of *garri* using supplements from other plant materials to produce different qualities. To the best of our knowledge, no research has been carried to produce *garri* supplemented with mango fruit mesocarp flour. It is believed that processing mango fruit mesocarp into flour and adding it as a supplement to *garri* produced from cassava roots will improve the nutritional quality, greatly reduce postharvest losses in cassava roots and mango fruits, combat hunger, enhance the health and socioeconomic status of consumers and farmers alike, and introduce a new variety of *garri* product to the consumers with better organoleptic quality attributes. The study was therefore, designed to evaluate the effect of using mango fruit mesocarp flour as a supplement on the functional, physicochemical and sensory properties of *garri*.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Freshly harvested and matured Cassava roots (*Manihot esculenta*) were procured from the Research farm of the Department of Crop Science, University of Agriculture, Makurdi, while freshly harvested, matured and moderately ripe mango fruit (*Brokin*) were purchased from Wurukum market in Makurdi Metropolis. Chemicals of analytical grade were used for the present research. Equipment were supplied by laboratories under Centre for Food Technology and Research, Benue State University and in Department of Food Science and Technology, University of Agriculture, Makurdi, respectively.

2.2 Sample Preparations

2.2.1 Mango fruit mesocarp flour production

Mango fruit mesocarp flour was produced following a previous method described by Sengev *et al.* [17] with some modification. Briefly, 25 kg of matured moderately-ripe mango fruits, *Mangifera indica* (*Brokin* variety) were sorted, washed, peeled and the mesocarp manually sliced (1.50 – 2.50 mm thick) using clean stainless steel kitchen knife. The slices of mango mesocarp were spread on a tray covered with aluminum foil to avoid non-enzymic browning as a result of direct contact of the slides with the metal tray and oven-dried at 60-70˚C for 24 h to a moisture content of about 10%. It was then milled after cooling, using disc attrition mill (Model: AII Asiko, Nigeria) and sieved through a 0.5 mm sieve to obtain mango fruit mesocarp flour.

2.2.2 Cassava mash production

The cassava mash was produced using an earlier method of Arisa *et al*. [15] with slight modification. 18 kg of the cassava roots were washed, peeled manually, rewashed to remove sand and pieces of unwanted materials and grated using mechanical grater to obtain the cassava mash. The cassava mash was bagged and allowed to ferment for 48 h. Following fermentation, the cassava mash was dewatered in a hydraulic press and the cake sifted (to remove fibrous materials from the cassava cakes) using a raffia woven sieve (0.3 x 0.3 cm pore size).

2.2.3 Procedure for *garri* production from cassava mash and mango fruit mesocarp flour

The blend formulations of the cassava mash and mango fruit mesocarp flour were made up of three different treatments, in addition to the control, with each sample weighing 4 kg as shown in Table 1. *Garri* was produced using modified method of Amponsah [2]. A large frying pan was set on fire and allowed to heat for about 5 min. The treatments were roasted separately for about 15 min by constant stirring to prevent lumping, scotching and to ensure even heating of the granules. The products obtained were designated as: $C_{100}M_0G$, $C_{90}M_{10}G$, $C_{80}M_{20}G$ and $C_{70}M_{30}G$ respectively. All the roasted *garri* samples were cooled, packaged and stored until used for analyses.

Table 1. Blend formulations containing different treatments for the production of enhanced *garri*

Treatment	Sample code	Ration	Weight of Cassava mash		Weight of Mango fruit mesocarp flour	
			Kg	%	Kg	%
T_1	$C_{100}M_0G$	1:0	4.0	100	0.0	00
T_2	$C_{90}M_{10}G$	9:1	3.6	90	0.4	10
T_3	$C_{80}M_{20}G$	4:1	3.2	80	0.8	20
T_4	$C_{70}M_{30}G$	7:3	2.8	70	1.2	30

$C_{100}M_0G$= 100% Cassava mash: 0% Mango fruit mesocarp flour (Control); $C_{90}M_{10}G$= 90% Cassava mash: 10% Mango fruit mesocarp flour; $C_{80}M_{20}G$= 80% Cassava mash: 20% Mango fruit mesocarp flour and $C_{70}M_{30}G$= 70% Cassava mash: 30% Mango fruit mesocarp flour.

2.3 Determination of proximate composition

The moisture, crude protein, fats, fibre and ash contents of the formulated *garri* samples were determined according to the standard methods of AOAC [18].The total carbohydrate was determined by difference: % Carbohydrate = 100% – (% moisture + % protein + % fat + % crude fiber+ % ash).

2.4 Determination of vitamin and elemental composition

The vitamin and mineral content profile of vitamin A, vitamin C, Calcium, potassium and sodium inherent in the *garri* samples were determined according to methods previously described by AOAC [18].

2.5 Determination of functional properties

The Bulk density was determined by the method of AOAC [19]. Water absorption capacity was determined by the method of Abu *et al*. [20] and Swelling capacity by the method of Leach *et al.* [21].

2.6 Sensory Evaluation

The organoleptic characteristics of the *garri* samples were evaluated by a 20 member trained panelists drawn from Centre for Food Technology and Research, Benue State University, Makurdi, comprising both staff and students who were already familiar with the consumption of *garri*. Each of the *garri* samples were soaked in slightly cold portable drinking water. All samples were uniformly sweetened with equal amount of sugar and presented to the panelists in disposable cups with spoons for scooping. The panelists were provided with a questionnaire. The samples were evaluated for appearance, aroma, taste and general acceptability using a 9-point hedonic scale in which 9 = like extremely and 1 = dislike extremely as previously used by Meilgaard *et al.* [22]. The order of presentation of samples to the panel was randomized. Tap water was provided for each panelist to rinse their mouth in-between evaluations.

2.7 Statistical analysis

The data obtained were subjected to Analysis of Variance (ANOVA) and Duncan Multiple range test was used to separate means where significant differences existed and data analyses was achieved using the Statistical Package for Social Statistics (SPSS) software version 20.0.

Results on the *garri* samples were expressed on a dry weight basis. All analyses were performed in triplicate determinations.

3. RESULTS AND DISCUSSION

3.1 Effect of mango fruit mesocarp flour supplementation on the proximate composition of *gari*

Results of proximate compositions (moisture, fat, crude fibre, protein, ash and carbohydrate) of the formulated *garri* blends are presented in Table 2. The moisture and crude fibre contents of the cassava-mango *garri* samples decreased, while the protein, ash and carbohydrate contents increased with increasing addition of mango fruit mesocarp flour. The crude fat was negligible in all samples. Moisture plays a very important role in the keeping quality of foods and high moisture can have an adverse effect on their storage stability [23]. The moisture contents of the formulated blends of *garri* were low. The low moisture content in foods could be as result of some of the water being tightly bound to food matrixes thereby making it unavailable to food pathogens proliferative activities [24] and may promote shelf life stability of the formulated *garri* samples. The result obtained for moisture contents in the present study were in agreement with that of Olaoye *et al.* [23] and Oluwamukomi [13] who also reported values less than 13% for *garri* samples produced from bitter and sweet cassava varieties, and sesame enriched *garri* respectively. Moisture content of *garri* is dependent on extent of roasting, particle size distribution and fermentation time [5]. The reduction of the fibre content observed in this study might have been due to the dilution effect of the supplement on the fibre content of "*garri*" [25]. However, the crude fibre content of cassava-mango *garri* blends reported in this study were higher than those reported by Bamidele *et al.* [26], Karim *et al.* [27], and Agbara and Ohaka [5] who reported values of 1.53-2.19%, 1.93-1.98% and 1.21-1.92% for cassava-cocoyam *garri*, cassava-sweet potato *garri* and melon seed meal enriched *garri* (produced from cassava, sweet potato and Irish potato), respectively. Crude fibre enhancement is beneficial to *garri* consumers since dietary fibre is believed to reduce the incidence of colonic cancer, diabetes, heart and certain digestive diseases [5].The protein, ash and carbohydrate contents of the fortified blends were higher than the unfortified *garri* sample (control). This could be attributed to the incorporation of the mango fruit mesocarp flour in the blends. The protein content of 1.01-1.42% obtained in this study was lower than those of Kure *et al.* [28] who reported values of 2.56-3.58% for sweet potato *garri*. Cassava roots and mango fruits are generally poor sources of protein. Ash content of a food product is an indication of its total mineral element content [24]. The increase in ash content of *garri* blends with increasing levels of substitution may be as a result of the relatively high ash content of the mango fruit mesocarp flour. Sengev *et al.* [29] reported ash content of mango mesocarp flour to be 2.7%. This is an indication that the blends are good repository of minerals. This implies that the formulated cassava-mango *garri* could be harnessed in mitigating the effects associated with inadequate micronutrient intakes affecting people especially in developing economies. Carbohydrate is a fuel provider to the body. The carbohydrate content of a food material indicates its glycemic index (i.e. its impact on blood glucose level upon digestion and absorption) [24]. The significant variation in carbohydrate content may be attributed to alterations in other constituents (protein, fat, ash fibre and moisture) [29].

Table 2. Effect of mango fruit mesocarp flour supplementation on the proximate composition of *garri*

Constituents	***Garri* sample**				
	$C_{100}M_0G$	$C_{90}M_{10}G$	$C_{80}M_{20}G$	$C_{70}M_{30}G$	**LSD**
Moisture (%)	12.60^{a}	9.40^{b}	8.55^{b}	7.85^{b}	-
Protein (%)	1.01^{a}	1.30^{a}	1.37^{a}	1.42^{a}	0.50
Fat (%)	<0.001	<0.001	<0.001	0.001	0.41
Crude fibre (%)	2.93^{a}	2.61^{a}	2.37^{a}	2.30^{a}	-
Ash (%)	0.47^{c}	0.80^{b}	1.21^{a}	1.28^{a}	-
Carbohydrate (%)	82.99^{a}	85.89^{b}	86.50^{b}	87.15^{b}	-

Values are means of triplicate determinations. Means with the same superscript in a row are not significantly different. $C_{100}M_0G$= 100% Cassava mash: 0% Mango fruit mesocarp flour (Control); $C_{90}M_{10}G$= 90% Cassava mash: 10% Mango fruit mesocarp flour; $C_{80}M_{20}G$= 80% Cassava mash: 20% Mango fruit mesocarp flour and $C_{70}M_{30}G$= 70% Cassava mash: 30% Mango fruit mesocarp flour

3.2 Effect of mango fruit mesocarp flour supplementation on some vitamin and elemental composition of *Garri*

Results of the vitamin and elemental composition of the formulated cassava-mango *garri* blends are presented in Table 3. Vitamin A, Vitamin C, calcium, potassium and sodium, all showed an increase as a result of inclusion of 10%, 20% and 30% of mango fruit mesocarp flour to the blend formulations. Samples supplemented with mango fruit mesocarp flour had higher vitamin A and vitamin C profile than the control. They also differed significantly among one another. Vitamin A promotes good vision, immune system integrity, growth, cellular differentiation and proliferation. Deficiency of vitamin A is more pronounced in third world countries and occurs mainly in children under the age of 5 years. This can lead to blindness and it is responsible for most cases of blindness in children. This explains why vitamin A fortification of food is very important. Vitamin C is involved in protein metabolism, collagen synthesis and an important physiological antioxidant [30]. The mineral elements were highest in the cassava-mango *garri* sample containing 70% Cassava mash and 30% Mango fruit mesocarp flour. Mineral elements are required in humans in trace amounts to maintain good health; excess of it might be toxic [24]. The amount of metal ions in the cassava-mango *garri* blends observed in Table 3 is commensurate with the ash content values presented in Table 2. Calcium is particularly higher than the other mineral elements in all the samples evaluated. This shows that the *garri* samples are a better source of Calcium than Potassium and Sodium. Calcium is helpful in the formation of strong bone and teeth, preventing osteoporosis and osteomalacia [31]. Potassium is useful in the prevention of hypertension [31]. Potassium influences the contraction of smooth, skeletal, and cardiac muscles and profoundly affects the excitability of nerve tissue [24]. Within the body, sodium play important roles in the maintenance of fluid balance, nerve transmission/impulse conduction and muscle contraction [24]. Inadequate intake of micronutrients (minerals) has been associated with severe malnutrition, increased disease conditions and mental impairment [32].

Table 3. Effect of mango fruit mesocarp flour supplementation on some vitamin and elemental composition of *garri*.

Nutrient	***Garri* sample**			
	$C_{100}M_0G$	$C_{90}M_{10}G$	$C_{80}M_{20}G$	$C_{70}M_{30}G$
Vitamin A (µg/100g)	3.00^d	50.31^c	100.81^b	160.66^a
Vitamin C (mg/100g)	10.23^d	20.18^c	28.18^b	33.34^a
Ca (%)	0.43^d	0.61^c	0.89^b	1.04^a
K (%)	0.07^a	0.11^a	0.16^a	0.28^a
Na (%)	0.05^a	0.09^a	0.15^a	0.22^a

Values are means of triplicate determinations. Means with the same superscript in a row are not significantly different.
$C_{100}M_0G$= 100% Cassava mash: 0% Mango fruit mesocarp flour (Control); $C_{90}M_{10}G$= 90% Cassava mash: 10% Mango fruit mesocarp flour; $C_{80}M_{20}G$= 80% Cassava mash: 20% Mango fruit mesocarp flour and $C_{70}M_{30}G$= 70% Cassava mash: 30% Mango fruit mesocarp flour. Ca= Calcium, K=Potassium and Na=Sodium.

3.3 Effect of mango fruit mesocarp flour supplementation on some functional properties of *garri*

Results of the functional properties of *garri* from blends of cassava mash and mango fruit mesocarp flour are shown in Table 4. The results revealed that the higher the percentage of mango fruit mesocarp flour in the formulated *garri*, the lower will be the bulk density, water absorption capacity and the swelling capacity. Similar trend was reported by Hounyèvou *et al.* [14] for *garri* processed from yam bean and cassava tubers. Table 4 showed that the addition of mango fruit mesocarp flour did not significantly affect the bulk density of the blend formulations, although the numerical value of the control sample ($C_{100}M_0G$) was higher (0.66 g/ml) than the rest of the samples (0.51-0.54 g/ml). The bulk density values reported in this study were comparable to those obtained by Agbara and Ohaka [5] who reported values of 0.54 – 0.67 g/ml for *garri* produced from Cassava, Irish and Sweet potatoes supplemented with melon seed meal. Bulk density gives an indication of the relative volume of packaging material required [17]. Aside the control, WAC of samples supplemented with mango fruit mesocarp flour did not show any significant difference. WAC decreased from 2.11 g/g in 100% cassava *garri* ($C_{100}M_0G$) to 1.30 g/g in 70%: 30% cassava-mango *garri* ($C_{70}M_{30}G$). Water holding capacity measures the extent to which macromolecules can entrap large amount of water without the possible incidence of exudation [33]. It depends on several often interrelated factors such as the nature of the molecules, presence of lipids, hydrophilic and hydrophobic balance in the molecule, thermodynamic properties of the system (such as bond energy and interfacial tension) as well as the physicochemical environment such as pH, ion concentration, temperature and pressure [20]. The swelling capacity in the fortified *garri* samples were lower (0.78-0.83 g/g) than the control sample (1.09 g/g). The lowering effect of enrichment on swelling index of fortified products can be attributed to reduce starch component in the enriched samples leading to lower capacity of the samples to absorb water [33]. A good *garri* should swell thrice its dry volume and a bulk density of 0.55 – 0.82 g/ml [5].

Table 4. Effect of mango fruit mesocarp flour supplementation on some functional properties of *garri*

Parameter	*Garri* sample				LSD
	$C_{100}M_0G$	$C_{90}M_{10}G$	$C_{80}M_{20}G$	$C_{70}M_{30}G$	
Bulk density (g/ml)	0.66^a	0.54^a	0.53^a	0.51^a	0.14
WAC (g/g)	2.11^a	1.63^b	1.56^b	1.30^b	-
Swelling capacity (g/g)	1.09^a	0.83^b	0.80^b	0.78^b	-

Values are means of triplicate determinations. Means with the same superscript in a row are not significantly different. $C_{100}M_0G$= 100% Cassava mash: 0% Mango fruit mesocarp flour (Control); $C_{90}M_{10}G$= 90% Cassava mash: 10% Mango fruit mesocarp flour; $C_{80}M_{20}G$= 80% Cassava mash: 20% Mango fruit mesocarp flour and $C_{70}M_{30}G$= 70% Cassava mash: 30% Mango fruit mesocarp flour. WAC=Water Absorption Capacity

3.4 Effect of mango fruit mesocarp flour supplementation on the organoleptic attributes of *garri*

The mean sensory scores for the soaked *garri* are presented in Table 5. The results indicated there was preference for $C_{70}M_{30}G$ on the basis of appearance (7.0), aroma (7.9), taste (7.5) and general acceptability (7.3). The sensory evaluation of the *garri* samples showed that the higher the percentage of mango fruit mesocarp flour inclusion, the better were the sensory scores. This implies that the incorporation of mango fruit mesocarp flour to the original unfortified *garri* was able to improve the organoleptic attributes to a reasonable level. The result also revealed that the organoleptic attributes of taste and general acceptability did not differ significantly in all the samples.

Table 5. Effect of mango fruit mesocarp flour supplementation on the organoleptic attributes of *garri*

Attribute	*Garri* sample				LSD
	$C_{100}M_0G$	$C_{90}M_{10}G$	$C_{80}M_{20}G$	$C_{70}M_{30}G$	
Appearance	6.5^b	5.7^c	7.0^a	7.0^a	-
Aroma	5.7^b	5.8^b	6.5^a	7.9^a	-
Taste	7.4^a	6.0^a	7.0^a	7.5^a	1.77
General acceptability	6.5^a	5.9^a	6.6^a	7.3^a	1.42

Values are means of triplicate determinations. Means with the same superscript in a row are not significantly different. $C_{100}M_0G$= 100% Cassava mash: 0% Mango fruit mesocarp flour (Control); $C_{90}M_{10}G$= 90% Cassava mash: 10% Mango fruit mesocarp flour; $C_{80}M_{20}G$= 80% Cassava mash: 20% Mango fruit mesocarp flour and $C_{70}M_{30}G$= 70% Cassava mash: 30% Mango fruit mesocarp flour.

4. CONCLUSION

This work has revealed that it is possible to produce *garri* with the inclusion of mango fruit mesocarp flour. Adding mango fruit mesocarp flour as supplement to the blend mixture to produce *garri* has the ability to enhance the macro- and micro-nutrient content, the functional properties and sensory characteristics of the product. Generally, increase in the mango fruit mesocarp flour concentration in the *garri* increased the protein, fat (negligible increase), ash, carbohydrate, vitamin A, vitamin C, calcium, potassium, sodium contents as well as organoleptic attributes of appearance, aroma, taste and general acceptability; while decreasing the moisture and crude fibre contents in addition to the bulk density, water absorption capacity and swelling capacity. Sensory evaluation showed that the most preferred blend formulation was $C_{70}M_{30}G$ containing 70% Cassava mash and 30% Mango fruit mesocarp flour.

ACKNOWLEDGEMENT

The authors acknowledge the contribution of Centre for Food Technology and Research, Benue State University for using her resources to provide some of the chemical reagents and equipment needed for conducting the present research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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