NUTRITIONAL, ANTIOXIDANT AND SENSORY PROPERTIES OF RICE-BASED *MASA* ENRICHED WITH GRAIN AMARANTH AND CARROT POWDER

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Abstract
This study is aimed at enhancing the nutritional properties of a staple street vended snack (masa) in Nigeria, with locally available, nutrients-dense, inexpensive and relatively underutilized food substances (grain amaranth and carrot). The blends of rice, grain amaranth and carrot (RGC) were prepared. Response Surface Methodology (optimal mixture design) was used to obtain four optimum sample mixtures based on moisture, protein, ash and vitamin A as response variables. Physical properties, proximate compositions, amino acids profile, minerals, vitamins contents, antioxidant and sensory attributes of the enriched masas were determined and compared with a negative control (100% rice flour masa). Results revealed a significant ($p < 0.05$) increase in protein, fat, ash and fibre contents of the enriched masas. Similarly, essential amino acids distributions in the enriched samples were within or above recommended dietary allowance except for lysine. Also, there were remarkable ($p < 0.05$) increases in minerals and vitamins. Vitamin A and C contents of masa samples ranged between 0.25 – 3.56 and 0.66 – 2.33 mg/100g, respectively. In the same vein, enrichment had positive effects on total phenol contents and antioxidant properties of the samples. However, control sample (100% rice-masa) was sensorially preferred by consumers with a mean score above 7 in all the sensory parameters considered. The study revealed that enrichment of rice with grain amaranth and carrots have the potential of raising the nutritional status of a low-protein rice-based snack (masa).

Keywords: Nutritional enrichment, Rice-based *masa*, Underutilized food substances, Optimal mixture design

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1. INTRODUCTION

Snacks are generally recognized as energy-dense and nutritionally poor foods and they include bakery items and sweetened beverages, usually eaten between main meals regardless of whether the food consumed is snack or not (Green, Siwajek, & Roulin, 2017). The perception of snacks as unhealthy foods stem from the list of items that belonged to this category. According to USDA classification – SR28, corn, rice and wheat-based foods are among the top of the list (USDA, 2018). In developing countries; Nigeria inclusive, the line between the main diet and snacking is so thin that many snack foods are considered part of regular staples. *Masa* is one of such indigenous street vended fermented puff batters that can be produced from maize, rice or millet and it's commonly consumed in the Northern region of the country. This region is faced with a prevalence of protein-energy malnutrition (PEM) and vitamin A deficiency (Abubakar *et al*., 2017). Over the years, enrichment of staple food products with locally sourced, high-protein and vitamin-rich food substances has been a valuable means of enhancing nutrient intakes in low-income countries (Darnton-Hill *et al*., 2017). However, the choice of these enhancers depends on many factors among which availability, accessibility and nutritional compositions take precedence.

Masa is predominantly a carbohydrate-based food but low in protein quality (Ochoa-Martinez *et al*., 2016). Like other cereal based food products, *masa* can be nutritionally fortified with the incorporation of other food substances. Grain amaranth is a relatively underutilized pseudo-cereal with exceptional nutritive values. The grain is fast growing in the country and has a potential of contributing immensely to nutrients intake in developing countries where the grain is abundant (Muyonga, Andabati, & Ssepuuya, 2014). High protein quality, presence of antioxidants and other bioactive phytochemicals in grain amaranth have been sufficiently reviewed in literature (Muyonga *et al*., 2014; Pazinatto *et al*., 2013; Alvarez-Jubete *et al*., 2010). It also reasonably high in essential amino acid – lysine; (which is absence in cereals) and sulphur-containing amino acids giving it a good balanced amino acids profile compare to most cereals. In addition, amaranth is endowed with important minerals such as calcium, potassium, magnesium, zinc and a good calcium/phosphorus (Ca:P) ratio range of 1 to 1.9 – 2.7 which is slightly higher than expected value (1 to 1.5) (Sharma, 2017). Therefore, inclusion of this grain to *masa* ingredients, have the potential of raising the nutritional status of the resultant product. Similarly, carrot is an economically important horticultural crop that has gained popularity in recent decades due to increased awareness of its nutritional value (Arscott and Tanumihardjo, 2010). Among many phyto-nutrients embedded in carrot, carotenoids – a group of fat soluble pigments (especially β-carotene – a precursor of vitamin A), account for the functional properties of carrots (Demiray & Tulek, 2017). Populations reputed for large consumption of fruits and vegetables rich in β-carotene have been shown to exhibit lower risk of some degenerative diseases.

Several attempts have been made to improve nutritional properties of rice-based *masa*. Nkama and Malleshi (1998) reported supplemented *masa* with cowpea or groundnut was nutritionally better than *masa* made from millet or rice alone. Ayo *et al.* (2012) discovered that enrichment of millet-based *masa* with beneseed paste improved the protein content of the composite *masa*. Samuel *et al.* (2015) reported that rice-based *masa* enriched with soybean and crayfish had improved nutritional qualities than 100 % rice *masa*. However, most if not all of these studies basically focused on improving the protein content of this product with little attention given to other functional properties. Hence, this study aimed at investigating the optimum blends of rice, grain amaranth and carrot powder required to produce *masa* of desirable nutritional, functional, sensorial and physical properties. The study has a potential of adding value to a traditional product; making it nutritionally more acceptable to a larger population.

2. MATERIALS AND METHODS

2.1. MATERIALS

2.1.1. Raw materials and flours preparation

Local rice and fresh carrot were obtained from Shasha market Akure, Ondo state, Nigeria. Baker's yeast (*Saccharomyces cerevisae*), "*kanwa*" (sodium bicarbonate) baking powder, salt, vegetable oil, onions and sugar were purchased at Oja-Oba Market, Akure, Ondo state, Nigeria. Grain amaranth was obtained from Lameco, Osogbo, Osun State, Nigeria. Local rice was sorted and extraneous materials were removed before milling into flour and stored in polythene bags until when used. Grain amaranth was washed properly, dried at a temperature of 65°C using hot air oven (TT-9054, Techmel and Techmel USA), milled into flour and packaged. Carrots were sorted, washed and shredded into very fine strips using a cooking cutter. The shredded carrots were blanched in 0.1% sodium metabisulphite solution at 90°C for 1 min, drained and oven-dried at 54°C. The dried carrots were milled into powder packaged airtight and stored until when used.

2.1.2. Formulation and optimization of enriched rice-based *masa* flours

The flour blends combination of rice, grain amaranth and carrot in percentage were determined using Optimal Mixture Design of Response Surface Methodology (Design Expert 9.0). Sixteen formulations were generated by the software and were analyzed for moisture, protein, ash and vitamin A contents as the dependent variables (Table 1). The desirability function approach (DFA) was used to simultaneously optimize the responses. Four optimum blends were selected for the enriched rice-based *masa* production and 100% rice flour was used as negative control (Table 2).

Table 1. Response Surface Optimization of rice-based *masa* flour blends with respect to some chemical parameters

Runs	Rice (g)	Amaranth (g)	Carrot (g)	Moi (%)	Ash (%)	Pro (%)	Vit.A (mg/100g)
1	70	15	15	11.3	1.4	17.07	8.5
2	70	20	10	9.1	1.3	17.13	9.05
3	67.5	20	12.5	9.9	1.9	16.75	11.55
4	66.32	18.69	15	8.9	1.5	18.38	10.28
5	69.95	17.56	12.49	10.9	1.6	14	23.8
6	69.95	17.56	12.49	10.5	1.8	16.75	17.5
7	66.37	19.84	13.79	9.6	1.7	15.82	13.73
8	65	20	15	11.4	1.7	17.5	13.6
9	69.01	16.97	14.02	7.9	1.7	14.44	13.3
10	68.06	18.47	13.47	18.4	1.7	16.69	8.35
11	67.5	20	12.5	10.2	2	14.44	11.55
12	69.08	19.33	11.59	11.4	1.9	17.13	13.75
13	70	15	15	8.8	1.7	11.38	12.05
14	67.51	17.49	15	12.9	2.2	17.07	12.15
15	69.95	17.56	12.49	10.3	1.9	14	14.2
16	67.51	17.49	15	9.8	2	13.13	13.5

Table 2. Optimum flour blends for production of enriched and control rice-based *masa*

Code	Rice	Amaranth	Carrot
RGC1	70.00	18.50	11.50
RGC2	66.70	20.00	13.30
RGC3	67.74	17.26	15.00
RGC4	67.50	17.50	15.00
R100	100.00	0.00	0.00

2.1.3. Preparation of rice-based masa enriched with amaranth grain and carrot

The four optimum blends were used in the preparation of *masa*. *Masa* was produced using a modified method of Igwe *et al.* (2013). Briefly, 210 g of rice was washed and a quarter of it (50.63g) was weighed and cooked. The remaining three-quarter (151.88 g) was soaked in 300 ml of distilled water for 5 hr. Then, the cooked and soaked rice were mixed and wet-milled into fine paste using 280 ml of distilled water. Grain amaranth flour (55.53 g), 34.47 g carrot powder and 1.8 g baker-yeast were added to the paste allowed to ferment for 3 hr. "*Kanwa"* water (24 ml), 18 g sugar and a pinch of salt were added to the fermented batter and stirred vigorously. Batter was taken using a medium-sized spoon and placed in a pan containing little amount of oil and fried for 5 – 8 min.

2.2. ANALYSIS

2.2.1. Physical properties

Weights of the *masa* ball in grams were taken using a calibrated weighing balance. The thickness and the width were measured using micrometer and ruler, respectively. Loaf volume was measured by small seeds displacement method (Greene & Bovell-Benjamin, 2004). Measurements were done in triplicate. The loaf and specific volume of the loaf were calculated using the following equations:

$$Loaf volume(cm^3) = \frac{w_2\,x w_1}{v_1}$$

Where w_2= weight of seed that filled the container, w_1= weight of seeds displaced by the loaf sample, v_1= volume capacity of the container

$$Specific volume\left(\frac{cm^3}{g}\right) = \frac{Loaf volume}{Loaf weight}$$

2.2.1. Proximate composition analyses
Standard official procedures described by AOAC (2005) were used in the determination of proximate compositions of the samples. Moisture content was determined using oven-drying method at 105^o C, protein (N x 6.25) by Kjedahl method, ash by igniting some sample in a furnace at 550°C, fat using the Soxhlet apparatus, crude fiber was determined after digestion, and carbohydrate by difference.

$Carbohydrate = 100 - (\%\ moisture + \%\ ash + \%\ protein + \%\ lipids + \%\ crude\ fibre)$.

2.2.2. Amino acids profile
Amino acids profile of the *masa* was determined using method described by Shaba *et al.* (2015). The sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon sequential Multi-Sample Amino Acid Analyzer (TSM).

2.2.3. Mineral Analyses
Zinc, potassium, phosphorus and magnesium were analyzed according to AOAC (2000) by placing 1 g of sample in platinum crucibles and calcined in a furnace at 450 °C for 6 h. The ash was dissolved in 5 ml $HNO_3/HClO_4$ (2/1), filtered to eliminate impurity. The minerals were analyzed by Atomic Absorption Spectrophotometer using a Perkin Elmer AAS-800 (Wellesley, MA).

2.2.4. Pro-vitamin A and vitamin C
Pro-vitamin A (β-carotene) content was determined according to the method of Bechoff (2011) and vitamin C content according to Benderitter *et al*. (1998) procedure using the ascorbic acid as the reference compound.

2.2.5. Antioxidant properties
Total phenol content (TPC) of the samples was determined by the method of Singleton *et al.* (1999). Briefly, phenolic extracts of *masa* (0.2 ml) was mixed with 2.5ml of 10% Folin Ciocalteu's reagent and 2 ml of 7.5% Sodium carbonate. The reaction mixture was incubated at 45°C for 40 min., and the absorbance was measured at 760 nm in the spectrophotometer. Gallic acid was used as standard phenol.
The reducing property of the extract was measured by the method of Pulido *et al.* (2000). The sample extract (0.25 ml) was mixed with 0.25 ml of 200 mM Sodium phosphate buffer pH 6.6 and 0.25 ml of 1% potassium ferricyanide (KFC). The mixture was incubated at 50 °C for 20 min, 0.25 ml of 10% Trichloroacetic acid was added and centrifuged at 2000 rpm for 10min. The supernatant (1 ml) was mixed with 1ml of distilled water and 0.1% of $FeCl_3$ and the absorbance was measured at 700 nm as ferric reducing property (FRAP).
Free radical scavenging ability of the extract against DPPH (1, 1-diphenyl-2-picryhydrazyl) was measured according to Gyamfi *et al.* (1999) method. The sample extract (1 ml) was mixed with 1ml of the 0.4 mM methanolic solution of the DPPH. The mixture was left in the dark for 30min before measuring the absorbance at 516 nm.
Determination of 2, 2'-azino-bis (3-ethylbenthiazoline-6-sulphonic acid) (ABTS) scavenging ability of the extract was determined according to the method described by Re *et al*. (1999). The ABTS was generated by reacting a 7 mM ABTS aqueous solution with $K_2S_2O_8$ (2.45 mM/l, final conc.) in the dark for 16 h and adjusting the absorbance at 734 nm to 0.700 with ethanol. About 0.2 ml of the appropriate dilution of the extract was then added to 2.0 ml of ABTS solution and the absorbance was read at 732 nm after 15mins. The TROLOX equivalent antioxidant capacity was subsequently calculated.

2.2.6. Sensory evaluation
Sensory attributes of the enriched and control *masa* samples were evaluated with 30 semi-trained panelists who are members of the

Department of Food Science and Technology with basic knowledge of food sensory assessment. Nine-point hedonic scale (1= dislike extremely to 9 = like extremely) was used to rank preferential scores. The panelists were served the *masa* samples randomly and sensory assessments were done with respect to aroma, appearance, taste, texture, finger feel, after taste and overall acceptability.

2.3. Statistical data analysis

All analyses were carried out in triplicate and data generated were subjected to One-Way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 17.0. The means were separated using Duncan's New Multiple Range Test (DNMRT) at 95% confidence level ($P < 0.05$).

3. RESULTS AND DISCUSSION

3.1. Selection of composite flour blends

Multi-response optimization (MRO) technique was used to simultaneous select the desirable and optimum samples (flour blends) with respect to multiple objectives (protein, pro-vitamin A, ash and moisture content) (Table 1). Four composite flour blends coded as RGC1, RGC2, RGC3 and RGC4 were selected for *masa* production and 100% rice as negative control sample (Table 2). The flour blends contained reasonable amounts of protein and pro-vitamin A. The selection of the responses was in pal with the ultimate objective of the study; which is to raise the nutritional status of rice-based *masa*.

3.2. Physical properties of rice-based masas

Inclusion of grain amaranth and carrot powder did not significantly influence the physical properties of the *masa* (Table 3). There was no significant change in thickness, while the length of control sample was slightly higher than others. However, RGC1 and RGC4 were comparatively similar with respect to weight and they were slightly higher than others. However, loaf volume was remarkably higher in RGC1 (196.67 - 200.57cm^3) than other formulations. RGC2 and RGC3 were significantly low among others; probably indicating the effect of higher percentage of carrot powder (15%) in both formulations. The high fibre contents of carrot may have negatively affected the loaf volume of *masa.* A similar observation was reported on addition of carrot pomace to wheat rolls (Kohajdová, Karovičová, & Jurasová, 2012). In the same vein, specific volumes of enriched *masa* were slightly lower than *masa* of 100% rice. This phenomenon could be attributed to the crippling effects of these supplementations on *masa* dough structure and subsequent lowering of gas retention during puffing as earlier implied by (Sivam *et al*. 2010).

Table 3. Physical characteristics of enriched and control rice-based *masa*

Samples	Thickness (cm)	Length (cm)	Weight (g)	Loaf Vol (cm^3)	Specific Vol (cm^3)
RGC1	1.98±0.10^a	6.03±0.05^{cd}	32.89±2.02^a	198.62±1.95^a	5.87±0.21^b
RGC2	1.90±0.10^a	6.40±0.10^{ab}	27.95±1.46^c	163.48±1.10^c	5.67±0.01^b
RGC3	1.95±0.86^a	5.83±0.15^d	28.53±0.42^c	162.32±1.5^c	5.64±0.04^b
RGC4	2.01±0.12^a	6.26±0.25^{bc}	31.17±0.25^{ab}	192.89 ±0.77^b	6.16±0.00^a
R100	1.83±0.05^a	6.63±0.11^a	29.97±1.52^{bc}	192.97±0.77^b	6.27±0.12^a

Means that do not share a letter (superscript) on the same column are significantly different at 95% confidence level ($P < 0.05$).
RGC1: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice.

3.3. Proximate composition

The proximate composition of *masa* enriched with grain amaranth and carrot powder are presented in Table 4. The results showed significant ($p < 0.05$) difference in moisture content which varied from 7.71 - 16.23 % with RGC1 and RGC4 having the least and highest values, respectively. Reports on the significance of moisture content in determining the keeping quality and shelf life of food product are abundant in literature (Adegunwa *et al*., 2012; Ajani *et al.*, 2012). Enriched samples were generally high in ash content with RGC1 and RGC3 having the highest. Samuel *et al.*, (2015) observed closely the same level of increment in ash content when rice *masa* was fortified with soybeans and crayfish. There was a minimum of 45% increase in ash content of *masa* on addition of grain amaranth and carrot powder. Similarly, fat and crude fibre and protein contents experienced remarkable increase relative to the enrichments. RGC2 and RGC3 had slightly higher fat contents; 23.45 and 22.42% respectively. A slightly higher fat content in enriched *masa* may be partly due to increased oil absorption of the batter during frying, due to the presence of carrot and amaranth flours. Ahmad *et al*., (2016) observed higher oil absorption capacity in wheat flour supplemented with carrot pomace. The enriched samples had higher fibre content which could be due to inclusion of grain amaranth and carrot powder. Carrot is a good source of dietary fibre (Dias, 2014). As expected, there was a significant improvement on the protein content of the enriched samples with all the four formulations having more than 10% crude protein content. This is in accordance to the earlier observation of Ayo *et al*., (2008) for *masa* obtained from different cereals. The carbohydrate content varied from 50.48 - 56.91% with all the *masa* samples qualify as rich sources of energy which is typical for snacks.

3.4. Amino acids profile

The most abundant amino acids in the enriched and control *masa* samples were glutamine, aspartate, arginine and leucine accounting for over 45% of the total amino acids in the samples (Table 5). This is in agreement with the report of Olagunju & Ifesan, (2013). Leucine is the dominant essential amino acid; over 7% in all the four formulations. However, control samples showed less than 6% leucine. The presence of grain amaranth and carrot powder had significant impacts on the quality of essential and non-essential amino acids profile of the *masa* samples when compared to the control and Recommended Dietary Allowance (RDA) (FAO/WHO, 1991). The health benefits of leucine and other branched amino acids such as isoleucine, valine, in enhancing nitrogen balance and preventing muscle wasting has been reported (Choudy *et al*., 2006). *Masa* of 100% rice showed comparatively lower essential amino acid with respect to the expected dietary requirements. However, all the four formulations had just up to 70% of the recommended amount of lysine. Being the limiting amino acid in most cereal-based foods (Vieira Bezerra *et al*., 2013), lysine contents of the enriched samples improved significantly ranging between 3.47 – 3.71% with RCG1 and RCG3 having the highest and lowest values, respectively. This is in agreement with the observation of Beswa *et al*., (2016) on addition of amaranth to biofortified maize snacks. The susceptibility of lysine to high temperature reaction (Maillard process) involving aldehyde groups of reducing sugars and e-amino group of lysine (Mariod *et al*., 2012), may be responsible for the low values of lysine in the *masa* formulations. Similarly, *masa* of 100% rice was inadequate with respect to virtually all the essential amino acids, making its enrichment a necessity.

3.5. Mineral and vitamin contents of the rice-based *masas*

The results of the mineral compositions of *masa* obtained from the four formulations and that of the control sample were presented with respect to potassium, phosphorus, magnesium, zinc and iron (Table 6). *Masas* enriched with the mixture of grain amaranth and carrot powder were significantly higher in potassium, phosphorus, magnesium and zinc than the control sample. The contributions of locally-sourced, plant-based enrichments on the mineral compositions of *puffy* snacks have been earlier supported (Jalgaonkar *et al*., 2018; Turksoy & Özkaya, 2011; Nkama & Malleshi, 1998).

There was no remarkable difference in the quantity of potassium among the four *masa* formulations. Several cross –sectional studies have revealed noteworthy positive associations between dietary potassium intake and bone health especially among the pre-, peri-, and postmenopausal women as well as aged men (Zhu *et al*., 2009; Tuckler *et al*., 1999). It electrolytic balance between sodium has also been linked with several noncommunicable ailments such as stroke and hypertension (USDA, 2018). Similarly, the value of phosphorus, magnesium, zinc, and iron of the enriched samples were within the acceptable values for human wellbeing as reported by USDA (USDA, 2016). However, the enrichment caused a significant ($p < 0.05$) decrease in magnesium and iron content of the enriched rice *masa*.

Table 4. Proximate composition (%) of enriched and control rice-based *masa*

Sample	Moisture	Total Ash	Crude fat	Crude fibre	Protein	Carbohydrate
RGC1	7.71±0.67^{e}	1.16±0.00^{b}	21.36±0.04^{c}	1.34±0.01^{d}	11.25±0.01^{b}	56.91±0.11^{a}
RGC2	12.54±0.06^{c}	0.86±0.02^{c}	23.45±0.06^{a}	1.42±0.01^{c}	11.51±0.01^{a}	50.48±0.01^{e}
RGC3	7.74±0.13^{d}	1.37±0.04^{a}	22.42±0.05^{b}	1.50±0.02^{b}	10.45±0.17^{c}	56.50±0.03^{c}
RGC4	16.23±0.03^{a}	0.89±0.01^{d}	19.51±0.02^{d}	1.56±0.01^{a}	10.24±0.00^{d}	51.54±0.05^{d}
R100	15.97±0.25^{b}	0.56±0.00^{e}	18.37±0.10^{e}	1.05±0.05^{e}	7.32±0.17^{e}	56.72±0.05^{b}

Means that do not share a letter (superscript) on the same column are significantly different at 95% confidence level ($P < 0.05$).
RGC1: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice. *Moi*: moisture; *Cfb*: crude fibre; *Pro:* protein; *Cho:* carbohydrate

Table 5. Amino acids profile of enriched and control rice-based *masa*

Amino acids	RGC1	RGC2	RGC3	RGC4	R100	***RDA**
Essential amino acids						
Valine	5.42	5.63	4.98	5.42	2.63	3.5
Leucine	7.08	6.53	7.74	7.08	5.84	6.6
Isoleucine	3.35	3.32	3.02	3.35	1.67	2.8
Methionine	2.33	2.34	2.62	2.33	0.58	2.2
Phenylalanine	5.18	4.46	4.83	5.18	2.49	2.8
Lysine	3.47	3.66	3.71	3.47	1.71	5.8
Histidine	2.13	2.15	2.2	2.13	0.34	1.9
Tryptophan	2.18	1.21	2.24	2.18	0.93	1.1
Threonine	3.47	3.39	3.64	3.47	1.69	3.4
Non-essential amino acids						
Glycine	4.75	4.45	3.28	4.75	2.11	--
Alanine	4.41	5.25	4.37	4.41	2.25	--
Serine	4.62	5.27	5.22	4.62	3.27	--
Proline	5.55	4.55	5.27	5.55	3.56	--
Aspartate	10.77	9.27	10.52	10.77	7.63	--
Glutamine	18.45	16.52	18.06	18.45	13.31	--
Arginine	8.94	8.24	7.57	8.94	4.46	2
Tyrosine	3.87	4.3	4.74	3.87	2.43	--
Cystine	1.86	2.21	2.7	1.86	0.22	--

RGC1: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice; *RDA:* Recommended Dietary Allowance (FAO/WHO, 1991).

Table 6. Minerals and vitamin compositions (mg/100g) of enriched and control rice-based *masa*

Sample	K	P	Mg	Zn	Fe	Vitamin A	Vitamin C
RGC1	638.00±2.00[a]	0.17±0.00[b]	21.33±2.08[ab]	0.34±0.01[ab]	0.22±0.08[b]	0.71±0.004[d]	1.31± 0.020[d]
RGC2	507.00±5.29[d]	0.17±0.00[b]	19.33±1.15[bc]	0.32±0.01[b]	0.19±0.00[c]	1.71±0.034[c]	1.33± 0.010[c]
RGC3	574.33±5.68[c]	0.11±0.00[c]	17.00±2.00[c]	0.25±0.17[c]	0.14±0.01[d]	3.56±0.015[a]	2.33± 0.008[a]
RGC4	594.66±2.51[b]	0.18±0.00[a]	17.66±0.57[c]	0.36±0.00[a]	0.21±0.00[b]	2.33±0.025[b]	1.65± 0.017[b]
R100	122.66±2.08[e]	0.10±0.00[d]	23.33±2.51[a]	0.23±0.02[c]	0.35±0.01[a]	0.25±0.013[e]	0.66 ±0.006[e]

Means that do not share a letter (superscript) on the same column are significantly different at 95% confidence level (P < 0.05). *RGC1*: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice.

Pro-vitamin A content of the *masa* ranged from 0.71 to 3.58mg/100g and samples containing 15% carrot powder (RGC3 and RGC4) were comparatively higher than others. As expected, pro-vitamin A contents of the *masa* increased with the proportion of carrot in the blends due to the presence of carotene pigment responsible for the color of carrot. The nutritional relevance of this pigment as a precursor of vitamin A has been well established (Sharma *et al.,* 2012). Therefore, enriched *masas* are nutritionally more valuable; as the least among them (RGC1), had more than twice vitamin A contained in the control samples. Vitamin C followed the same trend with vitamin A with RGC3 and RGC 4 having the highest values and control sample the lowest. The significance of vitamin C as antioxidant in foods; owing to its ability to donate electrons to recipient molecules, has been reported (Erdman *et al*., 2012). However, vitamin C retention in cereal-based products appears to be dependent on time, temperature and product moisture. Storage time and heating decrease ascorbic acid content (Stešková *et al*., 2006)which may be responsible for the lower residual vitamin C of the *masa* samples.

3.6. Antioxidant properties of rice-based *masas*

Table 7 shows that, in comparison to the control, there was a minimum of 40% increase in TPC for the enriched samples. *Masas* containing 15% carrot powder (RGC 3and RGC4) had higher TPC; which may be due to the antioxidative properties of carotene, vitamin c and other constituents. These compounds are capable of forming complex through electron transfer to form a blue chromophore quantifiable by spectrophotometric absorption (Blainski *et al*., 2013). Inclusion of carrot powder and grain amaranth improved TPC of enriched *masa* samples (P<0.05). There are verifiable evidences confirming health promoting properties of phenols (Omoba *et al.*, 2015). Thermolabile phenolic compounds may have been lost during frying of *masa* and this may explain the low residual total phenols in the products. Similarly, enriched *masas* exhibited better antioxidant capacities with respect to FRAP, ABTS and DPPH. Enriched samples RGC4 and RCG3 with 15% carrot powder, showed better radical scavenging capacities than other formulations. According to Sharma *et al*. (2012), carrot is one of the important root vegetables rich in bioactive compounds, phenolic compounds inclusive.

3.7. Sensory evaluation

Traditionally, rice *masa* is known for its characteristics sweet aroma, sour-sweet taste and creamy light-brown color (Efiuvwevwere & Ezeama, 1996). These quality attributes are partially connected to the activities of microorganisms during fermentation. Table 8 revealed that incorporation of grain amaranth.

Table 7. Total phenol content and antioxidant properties of enriched and control rice-based *masa*

Samples	TPC	FRAP	ABTS	DPPH (%)
RGC1	1.21±0.01c	3.25±0.03c	0.01±0.00d	40.06±0.40d
RGC2	0.98±0.01d	3.52±0.05bc	0.01±0.00c	43.43±0.90c
RGC3	1.41±0.00b	3.79±0.07b	0.01±0.00b	53.23±0.41b
RGC4	1.59±0.02a	5.07±0.34a	0.02±0.00a	59.23±0.46a
R100	0.87±0.01e	1.13±0.03d	0.007±0.00e	15.26±0.95e

Means that do not share a letter (superscript) on the same column are significantly different at 95% confidence level ($P < 0.05$).
RGC1: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice. *TPC:* Total phenol content (mg/100g); *FRAP:* ferric reducing ability of plasma; *DPPH:*1, 1- diphenyl-2-picryhydrazyl; *ABTS:* 2, 2'-azino-bis (3-ethylbenthiazoline-6-sulphonic acid).

Table 8. Sensory attributes of enriched and control rice-based *masa*

Attributes	RGC1	RGC2	RGC3	RGC4	R100
Aroma	$5.10±1.48^{c}$	$6.75±1.29^{b}$	$5.80 ± 1.24^{c}$	$5.70±0.98^{c}$	$8.05±0.89^{a}$
Color	$5.40 ± 1.70^{d}$	$6.70 ± 0.66^{b}$	$6.40 ± 1.50^{bc}$	$5.90 ± 0.79^{cd}$	$8.00 ± 1.03^{a}$
Taste	$4.65 ± 1.53^{c}$	$5.65 ± 1.27^{b}$	$5.75 ± 1.77^{bc}$	$5.65 ± 1.27^{b}$	$7.55 ± 1.39^{a}$
After taste	$4.35 ± 1.81^{c}$	$6.40 ± 1.93^{b}$	$5.05 ± 1.57^{c}$	$5.30 ± 1.66^{c}$	$7.55 ± 1.70^{a}$
Texture	$5.75 ± 1.12^{b}$	$5.70 ± 1.37^{b}$	$5.75 ±1.77^{b}$	$5.30 ± 1.30^{b}$	$7.30 ± 1.08^{a}$
Finger-feel	$5.30 ± 1.42^{b}$	$5.70 ± 1.56^{b}$	$5.40 ± 1.76^{b}$	$5.60 ± 1.39^{b}$	$7.45 ± 0.89^{a}$
Acceptability	$5.10 ± 1.55^{c}$	$6.60 ± 1.27^{b}$	$5.26 ± 1.66^{c}$	$5.75 ± 1.21^{bc}$	$7.75 ± 1.29^{a}$

Means that do not share a letter (superscript) on the same column are significantly different at 95% confidence level ($P < 0.05$).
RGC1: Masa of 70% Rice, 18.5% Grain amaranth & 11.5% Carrot powder; *RGC2*: Masa of 66.7% Rice, 20% Grain amaranth & 13.3% Carrot powder; *RGC3*: Masa of 67.74% Rice, 17.26% Grain amaranth & 15% Carrot powder; *RGC4*: Masa of 67.5% Rice, 17.5% Grain amaranth & 15% Carrot powder; *R100*: Masa of 100% Rice.

However, among the enriched samples RGC2 and RGC3 were comparatively more preferred to other blends with respect to aroma and color. Despite the color pigment of carrot and improved protein quality of grain amaranth, the control was still found superior to the enriched samples sensorially. RGC1 had taste and after-taste score of < 5.00. There were remarkable difference among the blends with respect to texture and finger-feel. The reduced percentage of rice in the enriched sample, may have adversely affected the rheological properties of *masa;* texture and finger-feel inclusive

Appreciable lower overall acceptability of enriched *masas* as compared to the control was due to the deviation from the normal organoleptic properties of traditional *masa* the panelists are conversant with.

4. CONCLUSIONS

The study aimed at improving the nutritional characteristics of rice-based *masa* with addition of highly nutritious, readily available and relatively under-utilized grain amaranth and carrot. The result indicated the possibility of producing value-added *masa* snack from a controlled blends of rice, carrot powder and grain amaranth flour. The inclusion of grain amaranth and carrot powder significantly improved the protein content, amino acid profile, pro-vitamin A, vitamin C as well as mineral compositions of the snack. *Masa* of 100% rice was ranked superior in all the sensory parameters considered. However, three out of four enriched *masa* formulations were found organoleptically satisfactory. Hence, a functional snack with improved nutritional values and health promoting potentials can be developed from blends of rice, grain amaranth flours and carrot powder.

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