Original Research Article

QUALITY EVALUTION OF NIGERIA BASE -MASA FROM BROKEN RICE ENRICHED WITH AFRICAN YAM BEAN AND CRICKET FLOUR BLENDS

ABSTRACT

Production and nutritional quality of Nigeria base -*Masa* from broken rice enriched with African yam bean and cricket blends was investigated. Broken rice, African yam bean and cricket were processed to flour using standard procedures. Blends of different proportions of broken rice, African yam bean and cricket were prepared at 100 %, 80/0/20 %, 80/20/0 % and 80/10/10 % respectively. The control sample was 100 % broken rice. The proximate, vitamins and minerals, antinutrients contents and sensory attributes of the *Masa* products were determined. The data obtained showed that moisture, protein, fat, ash carbohydrates and energy contents ranged from 38.46-44.48 %, 5.60-15.32 %, 0.71-9.71 %, 0.51-3.17 %, 0.61-0.79 %, 26.71-54.13 % and 245.25-270.77 kcal/100g respectively. The range values for vitamins and minerals are β-carotene (0.34-12.33 µg/100g), vitamin C (0.52-10.61 mg/100g), potassium (24.93-37.87 mg/100g), calcium (142.03-284.11 mg/100g), phosphorus (64.89-127.71 mg/100g), and iron (22.06-50.67 mg/100g). The antinutrients ranged from 0.095-1.860 mg/100g for alkaloids, 0.535-2.600 mg/100g for tannins, 0.040-1.550 mg/100g for phytates and 0.015-0.285 mg/100g for oxalates. The colour, aroma, taste, texture and general acceptability of the sensory attributes results ranged from 6.13-7.73, 6.60-7.07, 6.27-7.33, 5.93-6.73 and 6.67-7.73 respectively.

Keywords : broken rice; african yam bean; cricket; masa; vitamins; minerals.

1. INTRODUCTION

Masa is a fermented bread-like product, which is round in shape with brown smooth boy and crippling edges, made in Nigeria from pearl millet, maize or rice flour [1]; [2]; [3]. *Masa* is one of the varieties of fermented cereal-based foods and is a good source of income for the women who prepare this traditional product for sale [1]. '*Masa*' serves as breakfast and snack item [3]. *Masa*' is consumed in various forms by all aged groups in the middle belt and northern states of Nigeria. '*Masa*' results from frying of the fermented rice dough which is round in shape with brown smooth body and crippling edges.

Rice is a cereal which is used mainly for human food. The milling process of rice causes some loss of nutrients and breakage of some rice resulting in "broken rice." Little attention has been paid to the use of broken rice in Nigeria. Indeed, it is underutilized and often referred to as "poor man's food" in some societies because it is cheaper than unbroken rice and purchased mainly by those who cannot afford unbroken rice [4]. The use of flour from broken rice in products could significantly increase the utilization of broken rice grains; thereby reducing losses that are normally incurred with the locally processed rice grains in Nigeria.

Cricket powder may be used as a protein-rich additive. It should be pointed out that it is cheap and easy to produce, and is considered a good source of dietary protein [5]. Crickets are a valuable source of protein, unsaturated fatty acids, dietary fiber, vitamins and minerals [5]; [6]. Cricket powder obtained from these insects is characterized by high protein content (about 60–70 %), a lack of carbohydrates, and high iron and calcium content [6]. A FAO report explicitly recommends the use of insects as a source of easily digestible protein, especially in the face of rapid population growth in the world and the growing difficulty of providing sufficient food [7].

African yam bean is an herbaceous leguminous plant occurring throughout tropical Africa (United States Department of Agriculture [8]. African yam bean has attracted research interest because of its nutrient content. Amino acid analyses indicate that the lysine and methionine levels in the protein are equal to or better than, those of soybeans while most of the other essential amino acids corresponds to WHO/FAO recommendation. A protein content ranging between 20.2 and 21.2% has been reported for African yam bean by [9]. Its protein concentrate has been reported to be used in fortification of starchy foods like maize, cassava and *akamu* flours [9].

Fermented dough (Sourdough) is an important modern fermentation of cereal flours and water based upon an earlier spontaneous process [10]. The sourdough microflora is dominated by lactic acid bacteria and, along with yeast; they play a key role in cereals fermentation. The sourdough fermentation has a number of beneficial effects that include prolonged shelf life, accelerated volume gain, delayed staling, improved flavour, and good nutritional value. Sourdough has been reported to contribute to extended shelf life by inhibiting the growth of spoilage bacteria and moulds [10]. With the increasing number of people especially, the low income earners suffering from malnutrition and many health challenges, demand for product high in nutritional and medicinal value is increasing. The use of African Yam Bean flour and cricket powder in the enrichment of rice-based *Masa,* will enhance the nutritional and health status of the consumers. The use of flour from broken rice in products could significantly increase the utilization of broken rice grains; thereby reducing losses that are normally incurred with the locally processed rice grains. Therefore, the objective of this research was to evaluate the nutritional quality of *Masa* produced from broken rice enriched with African yam bean flour and cricket blends.

2. MATERIALS AND METHODS

2.1 Material Procurement

Broken rice (*Oryza sativa*), African Yam Bean (*Sphenostylis stenocarpa*) , and cricket (*Acheta domestica*), bakers yeast (*Sacharomyces cerevisiae)*, sugar, salt, oil, trona (sodium sesquicarbonate) were purchased from modern market Kaura-Namoda, Zamfara State Nigeria and were taken to the Department of Food Technology, Federal Polytechnic Kaura-Namoda for further processing.

2.2 Preparation of African Yam Bean Flour

African yam bean flour was prepared according to the method described by [11]. African Yam Bean was weighed, sorted, washed and sundried after fermentation for 48 hours. The roasted bean was coarsely grinded, winnowed to remove the seed coats and grinded into flour using attrition mill and sifted through 250 µm aperture sieve. Fine flour was then obtained and placed in sealed containers for further use. The flow chart showing the production of African yam bean flour is shown Figure 1.

2.3 Preparation of Cricket Powder

The method described by Adamina *et al*. [12] was used for the preparation of cricket powder. The cricket was cleaned, boiled then fried and was dried. The dried cricket was milled and finally packaged for further processing. This is as shown in Figure 1.

African Yam Bean Seeds

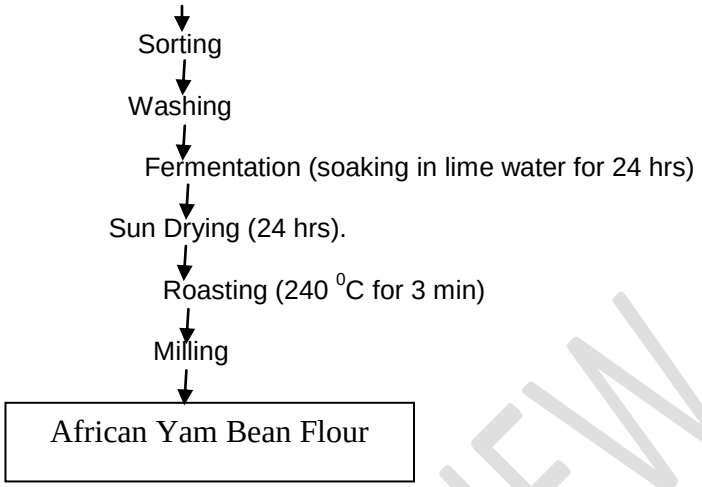

Figure 1: Flow Chart Showing the Production of African Yam Bean Flour

Source: Method described by [11] with modification

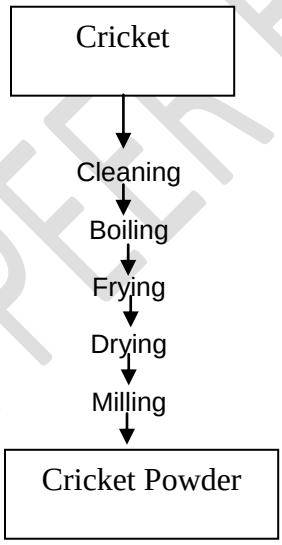

Figure 2: Flow Chart Showing the Production of Cricket Powder

Source: Method described by [12] with modification.

2.4 Preparation of *Masa*

Masa was produced according to the modified method described [13]. The composite flour was mixed together following the addition of rice grits, water, yeast, sugar and salt. The mixture was then fermented for 6 hours followed by the neutralization of the fermented mixture with *trona*. The portion was remixed to have even distribution of the *trona* and was then cooked at 5 mins.

Composite Flour (Broke rice, African yam bean and Cricket powder)

↓

Grits, water, yeast,
sugar and salt added

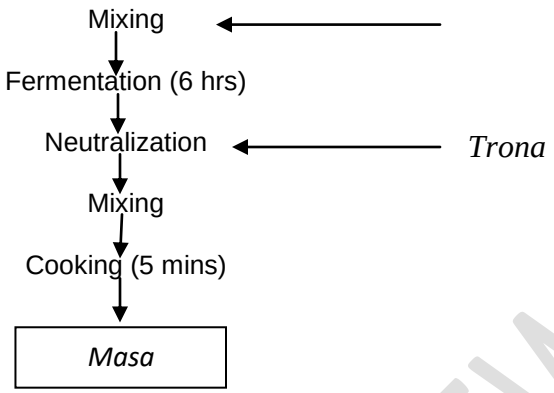

Figure 3: Flow Chart Showing the Production of *Masa*
Source: Method described by [13] with modification.

2.5 Blend Formulation for the Preparation of *Masa*

The criteria used for selecting the cereal-legume combination were based on Food and Agriculture Organization/ World Health Organization/UNU specifications of the daily protein and energy requirements for people of different ages, sexes, and levels of physical exertion.

Blends with different proportions of broken rice, African yam bean and cricket powder were prepared as shown in Table 1.

Table 1: Blend Formulation for the Production of *Masa* from Broken Rice, African Yam Bean and Cricket Powder

	Ingredient (%)		
Sample Code	**Broken Rice Flour**	**African Yam Bean Flour**	**Cricket Powder**
250	100	0	0
251	80	0	20
252	80	20	0
253	80	10	10

Table 2: Recipe Formulation for *Masa*

Component	*Masa* Composition
Flour *	1.25 kg
Sugar	15 g
Water	500 ml
Yeast and Baking powder	5 g
Trona	10 ml
Oil	12 ml
Salt	Pinch

***Broken Rice or Composite Flour**

Source: Method described by [1] with modification)

2.6 Determination of the Proximate Composition of *Masa*

The proximate composition of masa from broken Rice, african yam bean and cricket were determined according to the methods described by [14] and Carbohydrate content was determined by difference according to [15].

2.6.1 Moisture Content Determination

Moisture content was determined using the air oven dry method. A clean dish with a lid was dried in an oven (Uniscope Surgifriend Medicals, England) at 100 ^{0}C for 30 min. It was cooled in desiccators and weighed. Two (2) grams of sample was then weighed into the dish. The dish with its content was then put in the oven at 105 ^{0}C and dried to a fairly constant weight. The loss in weight from the original sample (before heating) was reported as percentage moisture.

$$\%\ Moisture = \frac{Weight\ Loss\ (W_2 - W_3)}{Weight\ of\ Sample\ (W_2 - W_1)}\ x\ 100$$

$Where$:

$W_1 = Weight\ of\ dish,$

$W_2 = Weight\ of\ dish + sample\ before\ drying,$

$W_3 = Weight\ of\ dish + sample\ before\ drying.$

2.6.2 Ash Content Determination

Two (2) gram of sample was weighed into an ashing dish which had been pre-heated, cooled in a desiccator and weighed soon after reaching room temperature. The crucible and content was then heated in a muffle furnace at 550 ^{0}C for 6 hrs. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The total ash was calculated as percentage of the original sample weight.

$$\%\ Ash = \frac{(W_3 - W_1)}{(W_2 - W_1)}\ x\ 100$$

$Where$:

$W_1 = weight\ of\ empty\ crucible, W_2 = weight\ of\ crucible + sample\ before\ ashing,$

$W_3 = weight\ of\ crucible + content\ after\ ashing$

2.6.3 Crude Fibre Determination

Two (2) grams of the sample was extracted using Diethyl ether. This was digested and filtered through the California Buchner system. The resulting residue was dried at 130 ^{0}C for 2 hrs, cooled in a dessicator and weighed. The residue was then transferred into a muffle furnace (Uniscope Surgifriend Medicals, England) and ignited at 550 ^{0}C for 30 min, cooled and weighed. The percentage crude fibre content was calculated as:

$$\%\ Crude\ Fibre\ = \frac{Loss\ in\ weight\ after\ incineration}{Weight\ of\ original\ food} \times 100$$

2.6.4 Crude Fat Determination

Fat was determined using Soxhlet method. Samples were weighed into a thimble and loose plug fat free cotton wool was fitted into the top of the thimble with its content inserted into the bottom extractor of the Soxhlet apparatus. Flat bottom flask (250 ml) of known weight containing 200 ml of hexane was fitted to the extractor. The apparatus was heated and fat extracted for 8 hrs. The solvent was recovered and the flask (containing oil and solvent mixture) was transferred into a hot air oven (Uniscope Surgifriend Medicals, England) at 105 ^{0}C for 1 hr to remove the residual moisture and to evaporate the solvent. It was later transferred into desiccator to cool for 15 min before weighing. Percentage fat content was calculated as

$$\%\ Crude\ Fat = \frac{weight\ of\ extracted\ fat}{Weight\ of\ Sample}\ x\ 100$$

2.6.5 Crude Protein Determination

The Kjeldahl method was used to determine the percentage crude protein. Two (2) grams of sample was weighed into a Kjeldahl digestion flask using a digital weighing balance (Uniscope Surgifriend Medicals, England: Max. 180 g). A catalyst mixture weighing 0.88 g (96 % anhydrous sodium sulphate, 3.5 % copper sulphate and 0.5 % selenium dioxide) was added. Concentrated sulphuric acid (7 ml) was added and swirled to mix content. The Kjeldahl flask was heated gently in an inclined position in the fume chamber until no particles of the sample was adhered to the side of flask. The solution was heated more strongly to make the liquid boil with intermittent shaking of the flask until clear solution was obtained. The solution was allowed to cool and diluted to 25 ml with distilled water in a volumetric flask. Ten (10) ml of diluted digest was transferred into a steam distillation apparatus. The digest was made alkaline with 8 ml of 40 % NaOH. To the receiving flask, 5 ml of 2 % boric acid solution was added and 3 drops of mixed indicator was dropped. The distillation apparatus was connected to the receiving flask with the delivery tube dipped into the 100ml conical flask and titrated with 0.01 HCl. A blank titration was done. The percentage nitrogen was calculated from the formula:

$$\%\ Nitrogen = \frac{(S-B)\times 0.0014\times 100\times D}{Sample\ Weight}$$

$$Where\ S = sample\ titre, B = blank\ titre, S - B = corrected\ titre, D = diluted\ factor$$

$$\%\ Crude\ Protein = \%\ Nitrogen \times 6.25\ (correction\ factor)$$

2.6.6 Carbohydrate Determination

Carbohydrate content was determined by difference according to Ihekoronye and Ngoddy (1985) as follows:

$$\%\ Carbohydrate = 100 - (\%\ Moisture + \%\ Ash + \%\ Fibre + \%\ Fat + \%\ Protein)$$

2.7 Determination of the Mineral Content (mg/100g) of *Masa*

The minerals contents were determined by the method described by [14].

2.7.2 Determination of Calcium

Calcium was determined using the atomic absorption spectrophotometer. Calcium carbonate (2.495 g) was dissolved and diluted to 100 ml with de-ionized water. This solution contains 1000 mg Ca2+ ions and from this stock solution, calcium standard of the following concentration levels 0.0, 3.0, 6.0, 9.0 were prepared. The absorbance of both the sample and the standard working aliquot were determined in the atomic absorption spectrophotometer (Uniscope Surgifriends, England) at 239.9 nm. The concentration of the test mineral in the sample was calculated with reference to the graph (standard curve) and obtained as follows:

$$Calcium = \frac{100 \times \mathrm{Y} \times \mathrm{Vf} \times \mathrm{D}}{\mathrm{W} \times 100 \times \mathrm{Va}}$$

$Where$

$W = weight\ of\ the\ sample\ analyzed$

$\mathrm{Y} = Concentration\ of\ Calcium\ obtained\ from\ the\ standard\ curve,$

$Vf = Total\ volume\ of\ extract$

$Va = volume\ of\ extract\ used$

$D = Dilution\ factor$

2.7.3 Determination of Phosphorus

Phosphorus was determined using spectrophotometer. Phosphorus in the sample was determined by the molybdate method using hydroquinone as a reducing agent. Sodium sulphate (1.0 ml), 1.0 ml of ammonium molybdate and 1 ml of hydroquinone were added to 1 ml of the sample digest. The mixture was agitated and allowed to stand for 30 minutes for the blue colour to develop. The absorbance of the sample was determined using the spectrophotometer at 600 nm. The phosphorus standard was prepared by dissolving 1.1 g of monobasic potassium phosphorus (KA_2 PO_4) into a 500 ml volumetric flask containing 500 ml of distilled water. Five drops of toluene were added to diminish microbial activity. Twenty millilitre of the Standard stock was collected and made up to 100 ml. This contained 100 ppm. Standard stock (0.1 ml) = 0.2 ppm. Zero to one millilitre of the 100 ppm phosphorus stock solution was poured into 100 ml volumetric flask separately and treated the same way as the sample. The reading of the standard was taken at 600 nm in UV/VIS spectrophotometer (Uniscope Surgifriend Medicals, England) and a standard curve was plotted.

$$P = \frac{100 \times \mathrm{Au} \times \mathrm{C} \times \mathrm{Vf}}{\mathrm{W} \times \mathrm{As} \times \mathrm{Va}}$$

Where

$W = Weight\ of\ sample\ analyzed$

$Au = Absorbance\ of\ test\ sample$

As =*Absorbance of standard phosphorus solution*

C =*Concentration (in mg/ml) of sample*

$Vf = Total\ vomule\ of\ extract$

Va =*Volume of extract analyzed*

2.7.4 Determination of Potassium

Potassium determination was by Flame Photometry. One (1) gram of sample was dissolved in 20 ml of acid mixture (650 ml of concentrated HNO_3; 80 ml PCA; 20 ml conc. H_2SO_4) and aliquots of the diluted clear digest were taken for photometry using Flame analyzer.

2.7.5 Determination of Iron

Standard solution containing 100 mg/ml of Fe^{3+} ions was prepared from 1 g pure iron wire. The wire was dissolved in 20 ml concentrated HNO3, boiled in water bath and diluted to 1000 ml with distilled water. Standard solutions with concentrations 0, 0.5, 1.0, 2.0 and 4.0 ppm was prepared. Two milliliter of sample aliquot was diluted to 100 ml and was used to determine the absorbance of the sample using an atomic absorption spectrophotometer (Uniscope Surgifriends Medicals, England) at 510 nm. The standard and samples absorbance were noted and concentration of iron in the sample was determined from the standard curve.

2.8 Determination of Anti-Nutritional Factors of *Masa*

2.8.1 Alkaloid Determination

The alkaloid content was determined gravimetrically by the method described by [16]. 5 g of each sample was weighed using a weighing balance and dispersed into 50 ml of 10 % acetic acid solution in ethanol. The mixture was well shaken and then allowed to stand for about 4 h before it is filtered. The filtrate was then evaporated to one quarter of its original volume on hot plate. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre-weighed filter paper was used to filter off the precipitate and it was then washed with 1 % ammonium hydroxide solution. The filter paper containing the precipitate was dried on an oven at 60 ^{0}C for 30 min, transferred into desiccators to cool and then reweighed until a constant weight was obtained. The constant weight was recorded. The weight of the alkaloid was determined by weight difference of the filter paper and expressed as a percentage of the sample weight analyzed. The experiment was repeated thrice for each food stuff sample and the reading recorded as the average of three replicates.

2.8.2 Determination of Tannins

Tannin was determined using the Folin-Denis spectrophotometer method described by [16]. The sample (0.5 g) was weighed into a conical flask and 100 ml of distilled water was added into it. This was gently boiled for one hour and then filtered using Whatman filter paper into a 100 ml capacity volumetric flask. The filter paper was re-washed with distilled water and the filtrate was diluted to 100 ml mark and then cooled. Fifty millilitre aliquot was put into each flask for the development of greenish-blue colour. Five millilitre of Folin – Denis reagent (100 g sodium tungstate, 20 g phosphomolybdic acid, 50 ml of 85 % phosphoric acid and 750 ml of water) and 10 ml of saturated sodium carbonate solution was added into it.

This was diluted to 100 ml mark with distilled water after a thorough mixing. The flask was allowed to stand in a water bath at 25 ^{0}C for one-half hour and the absorbance was measured in the UV/VIS spectrophotometer (Uniscope Surgifriend Medicals, England) at 760 nm. Distilled water was used as blank for the calibration curve. A standard curve was plotted and concentration of each sample was obtained and used for the tannin calculation.

$$Tannin\ mg/g = \frac{A_n \times C \times 100 \times V_f}{A_s \times W \times V_a}$$

$Where$
$A_n = Absorbance\ of\ test\ sample$
$A_s = Absorbance\ of\ standard\ solution$
$C = Concentration\ of\ standard$
$W = Weight\ of\ sample\ used$
$V_f = Total\ volume\ of\ extract$
$V_a = Volume\ of\ extract\ analyzed$

2.8.3 Determination of Oxalate

Oxalate was determined by the method described by [16]. This determination involved three major steps: digestion, oxalate precipitation and permanganate titration

Digestion

Two gram of sample flour was suspended in 190 ml of distilled water in a 250 ml volumetric flask. Ten millilitres of 6 ml HCL was added and the suspension was digested at 100 ^{0}C for1hour. It was cooled and made up to 250 ml before filtration.

Oxalate Precipitation

Duplicate portions of 125 ml of the filtrate were measured into beakers and four drops of methyl red indicator was added. This was followed by the addition of concentrated NH_4OH solution (drop wise) until the test solution changed from pink to a faint yellow colour. Each portion was then heated to 90 ^{0}C, cooled and filtered to remove precipitate containing ferrousion. The filtrate was again heated to 90 ^{0}C and 10 ml of 5 % $CaCl_2$ solution was added while stirred constantly. After heating, it was cooled and left overnight at 5 ^{0}C. The solution was then centrifuged at 2500 rpm for 5 minutes. The supernatant was decanted and the precipitate was completely dissolved in 10 ml of 20 % (v/v) H_2SO4 solution and then filtered for titration.

Permanganate Titration

The filtrate was made up to 300 ml. Aliquot of 125 ml from the filtrate was heated to near boiling and then titrated against 0.05 M standardized $KMnO_4$ solution to a faint pink colour which persisted for 30 seconds. The calcium oxalate content was calculated using the formula below.

$$\text{Oxalate (mg/g)} = \frac{T \times (V_{me})(D_f) \times 10^5}{M_E \times M_F}$$

$Where$
$T = Titre\ of\ KMnO4$
$V_{me} = Volume\ mass\ equivalent$
$D_f = Dilution\ factor$
$M_E = Molar\ equivalent\ of\ KMnO4$
$M_F = Mass\ of\ sample\ used$

2.8.4 Determination of Phytate

Phytate was determined using the method described by [16]. The sample was first extracted with 0.2 HCl. One millilitre of the extract was poured into a test tube fitted with a ground glass stopper together with 1ml of ferric solution. The ferric solution was prepared by dissolving 0.2 g ammonium iron (III) sulphate in 10 ml of 2 NHCl. The solution was then made up to 100 ml with distilled water. The tube was heated in a boiling water bath for 30 minutes, cooled in ice for 15 minutes and then allowed to reach ambient temperature. The content of the tube was centrifuged for 30 minutes (300 rpm). After centrifugation the supernatant (1 ml) was mixed with 1.5 ml of 2,2 bipyridne solution and the absorbance measured at 519 nm against distilled water using UV/VIS spectrophotometer (Uniscope Surgifriend Medicals, England). Thus, the phytic acid content is calculated as shown below.

$$\%\ \text{Phytic acid} = \frac{100 \times V_f \times C}{W \times V_a \times 100}$$

$Where$

$C = Concentration\ of\ curve\ ms/mole$
$Va = Total\ volume\ of\ extract\ analysed$
$Vf = Total\ volume\ of\ extract$
$W = Weight\ of\ sample$

2.9 Sensory Evaluation of the *Masa*

Sensory evaluation of the *Masa* samples was carried out according to the method described by [17]. A panel of twenty (20) members consisting of students and members of staff from Food Science and Technology Department, University of Agriculture Makurdi, Nigeria. Panelists were chosen based on their familiarity and experience with *Masa* for sensory evaluation. *Masa* produced from each flour blend, along with the reference sample were presented in coded form (A-C) and were randomly presented to the panelists. The panelists were provided with portable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (colour, aroma, taste, texture and overall acceptability) of the *Masa* samples was given to each panelist. Each sensory attribute was rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely). *Masa* was produced from broken rice flour (100 %) as control.

2.10 Statistical Analysis

The GENSTAT Statistical Software (version 17.0) was used for data analyses. Data were subjected to analysis of variance (ANOVA) and the separation of means was done using Fisher's Least Significant Difference (LSD) at (P<0.05).

3. RESULTS AND DISCUSSIONS

Table 3: Proximate Composition (%) of *Masa*

Samples	Moisture	Protein	Crude fat	Ash	Fibre	Carbohydrate	Energy (kcal/100g)
250	38.46^{d}±0.11	5.60^{d}±0.07	0.71^{d}±0.02	0.51^{d}±0.03	0.61^{b}±0.06	54.13^{a}±0.16	245.25^{d}±0.18
251	40.64^{b}±0.42	14.46^{b}±0.13	8.49^{b}±0.04	1.49^{c}±0.02	0.79^{a}±0.01	34.14^{c}±0.34	270.77^{a}±1.55
252	39.77^{c}±0.30	12.50^{c}±0.08	7.59^{c}±0.03	2.74^{b}±0.01	0.79^{a}±0.06	36.61^{b}±0.28	264.75^{b}±1.21
253	44.48^{a}±0.22	15.32^{a}±0.09	9.71^{a}±0.04	3.17^{a}±0.08	0.62^{b}±0.04	26.71^{d}±0.28	255.47^{c}±1.21
LSD	0.79	0.88	0.09	0.12	0.12	0.76	3.21

Values are mean± standard deviation of triplicate determination. Values with different superscript within the same column are significantly different at (P<0.05).

Key: 250= 100 % broken rice flour, 00 % African yam bean and 00 % cricket flour

251= 80 % broken rice flour, 00 % African yam bean and 20 % cricket flour

252= 80 % broken rice flour, 20 % African yam bean and 00 % cricket flour

253= 100 % broken rice flour, 10 % African yam bean and 10 % cricket flour

3.1 Proximate Composition of *Masa*

The proximate composition showed that the moisture content ranged from 38.46-44.48 %. The 253 sample had the highest moisture content (44.48 %) while sample 250 having the lowest (38.46 %). The protein contents of the *Masa* samples ranged from 5.60 % in the control sample to 15.32 % in the 253 sample. The highest protein content recorded in the 253 sample was due to the protein contents of cricket and African yam bean [18]. The results are similar with the findings of [19] and [1]. Fat acts as lubricating agent which improves the quality of food in terms of texture and flavour. Also, fat provides energy and is essential as it carries along fat soluble vitamins A, D, E and K [19]. The 253 *Masa* sample recorded the

highest fat content. This was followed by the 251 sample then the 252 and the lowest was recorded in the control. The highest value recorded in the 253 sample was as result of fat contents of cricket and African yam bean as reported by [20] and [21]. The ash contents of the *Masa* samples are significantly (P<0.05) different from each other. Ash content gives an insight to the mineral content of the food hence, the 252 and 253 samples can be described as good sources of minerals hence the relatively high-value of minerals recorded in them. The results obtained in this study are in agreement with similar reports by [19] and [22] for rice based *Masa* enriched with grain amatanth/carrot powder and pearl millet/cowpea/ groundnut respectively. The highest crude fibre content of *Masa* products was recorded in the 251 and 252 samples and showed no significant (p>0.05) different in their values. Fibre consumption has been linked to decreased incidence of heart disease, various types of cancer and diverticulosis [23]. Also, high levels of fibre in foods help in digestion of foods and contribute to the health of the gastrointestinal tract and system in man by aiding normal bowel movement thereby reducing constipation problems which can lead to colon cancer [24]. The high fibre contents of the 251 and 252 samples suggest that they would be ideal food for people suffering from obesity, diabetes, cancer and gastrointestinal disorders [25]. According to Schneeman [24], the crude fibre contributes to the health of the gastrointestinal system and metabolic system in man. Olamide *et al*. [19] and Nkama and Nagappa [22] reported close range of fibre contents in *Masa*. Carbohydrate provides heat and energy for all forms of body activities and as such its inadequacy can cause the body to divert proteins and body fat to produce needed energy and this might lead to depletion of body tissues [26]. There was a significant differentce (p<0.05) in the carbohydrate contents of the *Masa* samples. Supplementation of the broken rice with African yam bean and cricket significantly decreased the carbohydrate content. The highest content (54.13 %) was recorded in the control sample. This was followed by the 252 sample, then the 251 sample and the lowest was recorded in the 253 *Masa* sample. The observed decreased value was a result of high and low carbohydrate contents of broken rice and African yam and cricket respectively [27]. The energy content of the 251 *Masa* sample (270.77 kcal/100g) was significantly (p<0.05) higher than the energy contents of other samples. The least was recorded in the control sample (245.25 kcal/100g). The energy content of the various *Masa* products is high when compared to that of cassava products (flour and garri) (3.1-3.9 Kcal/100g) [28], which is considered as one of the main dietary energy source in Nigeria. The basis for the highest energy content of the 251 *Masa* sample could be attributed to the values of protein, fat and carbohydrate contents of the 251 sample.

Table 4: Vitamins and Mineral Composition of *Masa*

Samples	B-carotene (µg/100g)	Vitamin C (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)
250	0.34^{d}±0.01	0.52^{d}±0.08	24.93^{d}±0.88	143.03^{d}±0.86	64.89^{d}±0.77	22.06^{d}±0.09
251	4.06^{c}±0.14	4.39^{c}±0.09	28.89^{c}±0.09	174.19^{c}±0.79	98.92^{c}±0.58	35.46^{c}±0.21
252	12.33^{a}±0.06	10.61^{a}±0.08	33.11^{b}±0.08	194.42^{b}±1.55	122.99^{b}±0.61	42.62^{b}±0.06
253	9.50^{b}±0.09	9.98^{b}±0.04	37.87^{a}±0.04	284.11^{a}±1.41	127.71^{a}±0.81	50.67^{a}±0.79
LSD	0.25	0.22	2.21	3.33	1.95	1.15

Values are mean± standard deviation of triplicate determination. Values with different superscript within the same column are significantly different at (P<0.05).

Key: 250= 100 % broken rice flour, 00 % African yam bean and 00 % cricket flour

251= 80 % broken rice flour, 00 % African yam bean and 20 % cricket flour

252= 80 % broken rice flour, 20 % African yam bean and 00 % cricket flour

253= 100 % broken rice flour, 10 % African yam bean and 10 % cricket flour

3.2 Vitamins and Mineral Composition of *Masa*

The result of the vitamins and mineral contents of *Masa* are presented above; Vitamins are organic substances required only in small amounts in the body for metabolism. Their requirements are in milligrams (mg), micrograms (µg), milliequivalents (mEq) and international units (IU) (Chidinma *et al*., 2010). The 252 *Masa* sample (12.33 µg/100g) was significantly ($p<0.05$) higher than other samples. This was followed by the 253 sample (9.50 µg/100g) then the 251 sample (4.06 µg/100g) and the lowest content was recorded in the 250 *Masa* sample (0.34 µg/100g). The highest value recorded in the 252 sample was as a result of high β-carotene value of African yam bean [21], [18]. Also, the sample 252 recorded the highest vitamin C content among the samples due to its high value of Vitamin C. Abioye *et al*. [21] revealed significant presence of vitamin C in African yam bean. The values of the vitamin C recorded are significantly different ($p<0.05$).

Minerals are inorganic elements which are essential for the normal functioning of the body. They are required in smaller quantities in addition to proteins, carbohydrates, fats and vitamins, they are inorganic or "ash constituents" of foods which cannot be destroyed by heating [29]. Although they yield no energy, they have important roles to play in many activities in the body [15]. As ash content gives an insight to the mineral content of the food, hence, *Masa* produced from composite flour can be described as a rich source of minerals as seen from the significant ($P<0.05$) increased in the mineral contents of *Masa* with substitution levels of African yam bean and cricket.

Potassium activates several enzyme reactions and helps in the release of energy from carbohydrates, fats and proteins. It also functions with sodium and calcium to regulate neuromuscular excitability [29]. The potassium content of the *Masa* samples ranged from 24.93-37.87 mg/100g with sample 253 and 250 having the highest and lowest content respectively. Calcium is a mineral required by the body for a variety of physiological functions and the maintenance of bone tissues throughout life [30]. Calcium is necessary for supporting bone formation and growth; it also helps in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes and skin. The result of the calcium content of *Masa* samples showed that, the 253 sample was significantly ($p<0.05$) higher than all other *Masa* samples. Phosphorus works closely with calcium to build strong bones and teeth [29]. The highest phosphorus content of the *Masa* samples was found in the 253 *Masa* sample (127.71 mg/100g) and the lowest was found in the control sample (64.89 mg/100g). The iron content of the *Masa* products ranged from 22.06-50.67 mg/100g with the control and sample 253 having the lowest and highest iron values respectively. The results of the vitamins and mineral contents of *Masa* are higher than those reported by Olamide *et al*. [19] for rice-based *Masa*.

Table 5: Anti-nutrients Contents (mg/100g) of *Masa*

Samples	Alkaloids	Tannins	Phytate	Oxalate
250	0.095^{c}±0.05	0.535^{d}±0.02	0.040^{c}±0.01	0.015^{c}±0.01
251	0.145^{c}±0.01	0.615^{c}±0.02	0.060^{c}±0.00	0.030^{c}±0.00
252	1.860^{a}±0.01	2.600^{a}±0.04	1.550^{a}±0.01	0.285^{a}±0.01
253	0.345^{b}±0.01	1.640^{b}±0.01	0.270^{b}±0.06	0.140^{b}±0.01
LSD	0.09	0.09	0.09	0.02

Values are mean± standard deviation of triplicate determination. Values with different superscript within the same column are significantly different at ($P<0.05$).

Key: 250= 100 % broken rice flour, 00 % African yam bean and 00 % cricket flour

251= 80 % broken rice flour, 00 % African yam bean and 20 % cricket flour

252= 80 % broken rice flour, 20 % African yam bean and 00 % cricket flour

253= 100 % broken rice flour, 10 % African yam bean and 10 % cricket flour

3.3 Antinutritional Composition of *Masa*

The anti-nutritional contents of the *Masa* samples showed low levels of alkaloids, tannins, Phytate and oxalate. Sample 252 recorded the highest contents of antinutritional parameters due to the high content of anti-nutrients in African yam bean as presented in Table 5. Alkaloids have been reported to cause gastrointestinal and neurological disorder [31]**.** The alkaloid content of the 252 sample was significantly ($p<0.05$) the highest compared to other samples. This was due to the level of African yam bean substitution in the composite *Masa* and the presence of alkaloid in African yam bean [31]. Tannins are known for their ability to precipitate with iron and other metals, thereby reducing their absorption [32]. Tannin is an anti-nutrient that inhibits activity of digestive enzymes [33]. The lower values obtained (0.535-2.600 mg/100g) for tannin is very important because tannic acid above 10 % of total dry weight affects overall nutritional potential of food material. Importantly, tannin can be used in treatment of skin eruption due to their astringent properties [33].

Phytate has strong binding capacity and forms insoluble complexes with multivalent cations, including Ca, Mg, Fe and Zn, and render them biologically unavailable [33]. Phytate ranged from 0.040 mg/100g in the control *Masa* to 1.550 mg/100g in the 252 *Masa* sample.

Oxalates affect the metabolism of magnesium and calcium. It also reacts with proteins to form complexes which have an inhibitory effect in the digestion of peptic. High oxalate diet can increase the risk of renal calcium absorption and has been implicated as a source of kidney stone. Generally, small amounts of oxalate may occur in many vegetables and fruits but do not pose nutritional problems [33]. The levels of these anti-nutrients in all the samples were relatively low, below toxic levels and may not hinder the bioavailability of essential nutrients in the composite *Masa*s. Also, the levels observed here are not in considerable levels of inhibitors that may inhibit the absorption of minerals [32]. The results are similar to the findings of [35] but lower than the ones discovered in foods by [36].

Samples	Colour	Aroma	Taste	Texture	General Acceptability
250	6.13^{c}	6.67^{a}	7.20^{ab}	6.73^{a}	7.73^{a}
251	7.33^{ab}	7.07^{a}	6.27^{c}	6.33^{a}	6.67^{b}
252	7.73^{a}	6.33^{a}	7.33^{a}	5.93^{a}	7.73^{a}
253	6.80^{bc}	6.60^{a}	6.40^{bc}	6.13^{a}	6.67^{b}
LSD	0.68	1.08	0.86	1.07	0.77

Table 6: Sensory Attributes of *Masa*

Values with different superscript within the same column are significantly different at ($P<0.05$)

Key: 250= 100 % broken rice flour, 00 % African yam bean and 00 % cricket flour

251= 80 % broken rice flour, 00 % African yam bean and 20 % cricket flour

252= 80 % broken rice flour, 20 % African yam bean and 00 % cricket flour

253= 100 % broken rice flour, 10 % African yam bean and 10 % cricket flour

3.4 Sensory Attributes of *Masa*

Sensory evaluation is usually carried out towards the end of product development or formulation cycle and this is done to assess the reactions of consumers/judges about the product to determine the acceptability of such product. It is an important criterion for assessing quality in the development of new products and for meeting consumer requirements [37]. Colour is an important sensory attribute of any food because of its influence on acceptability. Sensory attributes of various Masa Products are presented in Table 6. The result of the colour of the various *Masa* samples differ significantly ($p<0.05$). Sample 252 (7.73) was the highest and the lowest was observed in the control (6.13) *Masa* sample.

Taste is a sensory parameter that affects the quality and acceptability of food products. No matter how rich or nutritious a food is, if it tastes bad, such food would not be accepted by people. Taste is the primary factor determining the acceptability of any product and has the highest impact in determining the market success of product. Sample 252 (7.33) taste better than other samples and the lowest was recorded in sample 251 (6.33).

General acceptability was determined on the basis of quality scores obtained from evaluation of colour, aroma, taste and texture. There was no significant ($p>0.05$) different in the *Masa* samples of 250 and 252 as they recorded same general acceptability. Also, between samples 251 and 253, there was not significant different ($p>0.05$) in their general acceptability. This results are similar with the findings of [19], [1] and [2].

4. CONCLUSION

The study showed that addition of African yam bean and cricket to broken rice in *Masa* production greatly increased the protein, fat, ash and fibre contents of *Masa*. Also, β-carotene, Vitamin C, potassium, calcium, phosphorus and iron contents of broken rice-based *Masa* increased with African yam bean and cricket addition. The ant-nutrients contents of the *Masa* products showed significant values at 20 % level of African yam bean substitution. Sensory analysis carried out in this study showed that *Masa* produced from 100 % broken rice and 20 % African yam bean substitution were generally accepted more than other *Masa* samples. Though they were most preferred, but the 20 % cricket addition and 10 % African yam bean and 10 % cricket substitution levels were also accepted.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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