Quality Evaluation of Nigeria Base-masa from Broken Rice Enriched with African Yam Bean and Cricket Flour Blends

O. A. Kure a*, S. Ibrahim b and I. Z. Inikpi a

a Department of Food Technology, Federal Polytechnic, Kaura Namoda, Zamfara State, Nigeria.
b Department of Hospitality Management, Federal Polytechnic, Kaura Namoda, Zamfara State, Nigeria.

Authors’ contributions

This work was carried out in collaboration among all authors. Author OAK designed the study, performed the statistical analysis. Author SI wrote the protocol, wrote the first draft of the manuscript and managed the analysis of the study. Author IZI managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2022/v41i531669

ABSTRACT

This research work highlight the production and nutritional quality of Nigeria base -Masa from broken rice enriched with African yam bean and cricket blends was investigated. 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 proximate, vitamins and minerals, antinutrients contents and sensory evaluation 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 %, 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, however masa

*Corresponding author: E-mail: bukkykure@gmail.com
produced from sample 250 (100:0:0 % broken rice:African yam bean: cricket ) and 252 (80:20:0 Broken rice: African yam bean:cricket) substitution were generally accepted more than other Masa samples.

Keywords: Broken rice; African yam bean; cricket; masa; vitamins; minerals.

1. INTRODUCTION

*Masa* can be defined as a fermented bread-like product, which are round in shape with golden brown smooth colour and crippling edges, which are mostly consumed in Nigeria and other parts of west African countries; produced from pearl millet, maize or rice flour [1]; [2]; [3]. *Masa* belong to one of the varieties of fermented cereal-based foods and are another source of income for the women who prepare this traditional product for sale [1]. *Masa* are mostly breakfast and snack item [3]. *Masa* are consumed in different forms by all aged groups in the northern and middle belt states of Nigeria; *Masa* are produced from frying of the fermented rice dough.

Rice is a group of cereal which is mostly used as human food. The milling process of paddy to rice mostly resulted in loss of some nutrients and breakage of some rice. In Nigeria little attention has been given to the broken rice. Indeed, it is underutilized and often referred to as “Average income 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 application of flour from broken rice in the production foods could significantly increase the utilization of broken rice grains; thereby reducing losses that are mostly experience with the locally processed rice grains in Nigeria.

Cricket powder can also be used as a protein-rich supplement. It is observed to be cheap and easy to produce, and is considered a good source of dietary protein [5]. Crickets are high in protein, unsaturated fatty acids, dietary fibre, vitamins, and minerals [5], [6]. Cricket powder has a high protein content (about 60–70%), a lack of carbs, and a high iron and calcium content [6]. Insects are specifically recommended as a source of highly digestible protein in an FAO report, especially in light of the world’s rapid population expansion and the increasing difficulty in providing enough food [7]. The African yam bean is a leguminous herbaceous plant that grows throughout tropical Africa (US Department of Agriculture [8]. The nutritional composition of the African yam bean has piqued researchers’ interest. The amounts of lysine and methionine in the protein are equivalent to or better than those in soybeans, according to amino acid assays, and the majority of the other necessary amino acids are in accordance with WHO/FAO recommendations. African yam bean protein content ranged between 20.2 and 21.2 percent [9]. Its protein concentration has reportedly been used to fortify starchy foods such as maize, cassava, and akamu flours [9]. Fermented dough (Sour dough) is a popular modern fermentation of cereal flours and water that evolved from a more natural method [10]. Lactic acid bacteria dominate the sourdough microflora, and they, together with yeast, play a key role in cereal fermentation. It has been shown to help extend shelf life by preventing the growth of spoiling bacteria and moulds [10]. With the increasing number of people especially, the average earners in Nigeria 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 utilization of flour from broken rice could significantly increase the acceptance and use in the food industries; 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*), baker’s yeast (*Sacharomyces cerevisiae*), sugar, salt, oil, trona (sodium sesquicarbonate C_{2}H_{2}Na_{3}O_{8}) 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

The process of [11] was used to make African yam bean flour. After 48 hours of fermentation, the African Yam Bean was weighed, sorted, cleaned, and sundried. The roasted bean was coarsely ground, winnowed to remove the seed coatings, then ground into flour using an attrition mill before being filtered through a sieve with a 250 µm aperture. 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 Fig. 1.

2.3 Preparation of Cricket Powder

The cricket powder was prepared in accordance of the method described by Adamina et al. [12]. 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 Fig. 2.

2.4 Preparation of Masa Sample

*Masa* was produced according to the method described by [13] with modification. 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.

2.5 Blend Formulation for the Preparation of Masa

Blends with different proportions of broken rice, African yam bean and cricket powder were prepared as shown in Table 2.

---

**Fig. 1. Flow Process Showing the Production of African Yam Bean Flour**

*Source: Method described by [11] with modification*
Fig. 2. Flow Process Showing the Production of Cricket Powder
Source: Method described by [12] with modification

Table 1. Recipe Formulation for Masa

<table>
<thead>
<tr>
<th>Component</th>
<th>Masa Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour *</td>
<td>1.25 kg</td>
</tr>
<tr>
<td>Sugar</td>
<td>15 g</td>
</tr>
<tr>
<td>Water</td>
<td>500 ml</td>
</tr>
<tr>
<td>Yeast and Baking powder</td>
<td>5 g</td>
</tr>
<tr>
<td>Trona</td>
<td>10 ml</td>
</tr>
<tr>
<td>Oil</td>
<td>12 ml</td>
</tr>
<tr>
<td>Salt</td>
<td>Pinch</td>
</tr>
</tbody>
</table>

*Broken Rice or Composite Flour
Source: Method described by [1] with modification

Composite Flour (Broke rice, African yam bean and Cricket powder)
- Grits, water, yeast, sugar and salt added

Fig. 3. Flow Process Showing Masa Production
Source: Method described by [13] with modification
Table 2. Blend Formulation for the Production of Masa from Broken Rice, African Yam Bean and Cricket Powder

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Broken Rice Flour (%)</th>
<th>African Yam Bean Flour (%)</th>
<th>Cricket Powder (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>251</td>
<td>80</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>252</td>
<td>80</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>253</td>
<td>80</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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 dried dish with a lid was dried in an oven (Uniscope Surgifriend Medicals, England) at 100 °C for 30 min. It was weighed after cooling in desiccators. The material was then weighed into the dish at two (2g) grammes. The dish, together with its contents, was then dried to a fairly consistent weight in the oven at 105°C. The percentage moisture loss from the original sample (before heating) was calculated.

\[
\text{% Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100
\]

Where:

\[
W_1 = \text{Weight of dish,}
\]
\[
W_2 = \text{Weight of dish + sample before drying,}
\]
\[
W_3 = \text{Weight of dish + sample after drying.}
\]

2.6.2 Ash Content Determination

Two (2g) 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 °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.

\[
\text{% Ash} = \frac{(W_2 - W_1)}{(W_2 - W)} \times 100
\]

Where:

\[
W_1 = \text{weight of empty crucible,}
\]
\[
W = \text{weight of crucible + sample before ashing,}
\]
\[
W_3 = \text{weight of crucible + content after ashing.}
\]

2.6.3 Crude Fibre Determination

Two (2g) 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 °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 °C for 30 min, cooled and weighed. The percentage crude fibre content was calculated as:

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

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 °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:
2.6.5 Crude Protein Determination

The Kjeldahl method was used to determine the percentage crude protein. Two (2g) grams of sample was weighed into a Kjeldahl digestion flask using a digital weighing balance (Uniscope-Surgifriend Medicals, England: Max. 180 g). A catalyst combination weighing 0.88 g was applied, consisting of 96 percent anhydrous sodium sulphate, 3.5 percent copper sulphate, and 0.5 percent selenium dioxide. 7 mL concentrated sulphuric acid was added and stirred to thoroughly combine the contents. The flask was slowly heated in the fume chamber at an inclined position until no particles of the sample stuck to the flask’s side. The solution was heated more vigorously to bring the liquid to a boil, and the flask was shaken intermittently until a clear solution was achieved. The solution was allowed to cool before being diluted to 25 mL in a volumetric flask with distilled water. A steam distillation equipment was used to transfer ten (10 ml) mills of diluted digest. With 8 mL of 40% NaOH, the digest was turned alkaline. 5 mL of 2% boric acid solution was then added to the receiving flask, along with 3 drops of mixed indicator. With the delivery tube dipped into the 100ml conical flask and titrated with 0.01 HCl, the distillation equipment was connected to the receiving flask. It was decided to conduct a blank titration. The formula was used to compute the nitrogen percentage:

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

Where \( S = \text{sample titre}, B = \text{blank titre}, S - B = \text{corrected titre}, D = \text{diluted factor} \)

\[
\% \text{ Crude Protein} = \% \text{ Nitrogen} \times 6.25 \text{ (correction factor)}
\]

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

The minerals contents (Calcium, Phosphorus, Potassium and Iron) were determined by the method described by [14].

2.7.1 Determination of Calcium

The atomic absorption spectrophotometer was used to determine calcium. Calcium carbonate (2.495 g) was dissolved in de-ionized water and diluted to 100 mL. This stock solution comprises 1000 mg Ca2+ ions, and calcium standards of the concentration levels 0.0, 3.0, 6.0, and 9.0 were created from it. 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:

\[
\text{Calcium} = \frac{100 \times Y \times Vf \times D}{W \times 100 \times Va}
\]

Where

\( W = \text{weight of the sample analyzed} \)
\( Y = \text{Concentration of Calcium obtained from the standard curve,} \)
\( Vf = \text{Total volume of extract} \)
\( Va = \text{volume of extract used} \)
\( D = \text{Dilution factor} \)

2.7.2 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 (\( \text{KA}_2\text{PO}_4 \)) 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.

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

*Where*

- $W = \text{Weight of sample analyzed}$
- $Au = \text{Absorbance of test sample}$
- $As = \text{Absorbance of standard phosphorus solution}$
- $C = \text{Concentration (in mg/ml) of sample}$
- $Vf = \text{Total volume of extract}$
- $Va = \text{Volume of extract analyzed}$

2.7.3 Determination of Potassium

Potassium determination was by Flame Photometry. One (1g) gram of sample was dissolved in 20 ml of acid mixture (650 ml of concentrated HNO$_3$; 80 ml PCA; 20 ml conc. H$_2$SO$_4$) and aliquots of the diluted clear digest were taken for photometry using Flame analyzer.

2.7.4 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 HNO$_3$, 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 measured gravimetrically using the methods mentioned in [16]. About (5g) of each sample was weighed using a weighing scale and dispersed into 50 ml of 10 percent acetic acid solution in ethanol. After a thorough shaking, the mixture was allowed to sit for around 4 hours before being filtered. On a heated plate, the filtrates were reduced to a fraction of their original volume. To precipitate the alkaloids, concentrated ammonium hydroxide was added drop by drop. The precipitate was filtered out using pre-weighed filter paper, which was then washed with a 1 percent ammonium hydroxide solution. The filter paper containing the precipitate was dried on an oven at 60 °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 experiments were 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 Whitman 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 °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.

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

*Where*

- $A_n = \text{Absorbance of test sample}$
- $A_s = \text{Absorbance of standard solution}$
- $C = \text{Concentration of standard}$
- $W = \text{Weight of sample used}$
- $V_f = \text{Total volume of extract}$

43
\[ V_a = Volume \ of \ extract \ analyzed \]

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 magnesium permanganate titration.

2.8.3.1 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 °C for 1 hour. It was cooled and made up to 250 ml before filtration.

2.8.3.2 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\(_4\)OH solution (drop wise) until the test solution changed from pink to a faint yellow colour. Each portion was then heated to 90 °C, cooled and filtered to remove precipitate containing ferrous ion. The filtrate was again heated to 90 °C and 10 ml of 5 % CaCl\(_2\) solution was added while stirred constantly. After heating, it was cooled and left overnight at 5 °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\(_2\)SO\(_4\) solution and then filtered for titration.

2.8.3.3 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.

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

Where

\begin{align*}
T &= \text{Titre of KMnO}_4 \\
V_{ne} &= \text{Volume mass equivalent} \\
D_f &= \text{Dilution factor} \\
M_E &= \text{Molar equivalent of KMnO}_4 \\
M_F &= \text{Mass of sample used}
\end{align*}

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 bipyridine 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

\begin{align*}
C &= \text{Concentration of curve ms/mole} \\
V_a &= \text{Total volume of extract analysed} \\
V_f &= \text{Total volume of extract} \\
W &= \text{Weight of sample}
\end{align*}

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 comprising students and members of staff from Food Science and Technology Department, Federal Polytechnic Kaura Namoda, Zamfara State, Nigeria. Panelists were chosen based on their familiarity and experience with Masa sample for sensory evaluation. Masa produced from each flour blend, along with the reference sample (from 100 % broken rice) 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 the data analyses. Data were subjected to analysis of variance using (ANOVA) and the separation of means were seperated using Fisher's Least Significant Difference (LSD) at (P<0.05).

3. RESULTS AND DISCUSSIONS

3.1 Proximate Composition of Masa

The proximate composition was presented on table 3, which 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 %). 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 agents that improve the quality of food in terms of texture and flavour. Also, fat provides energy and are 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 required energy; and this might lead to depletion of body tissues [26]. There was a significant difference (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) were significantly (p<0.05) greater 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.

3.2 Vitamins and Mineral Composition of Masa

The result of the vitamins and mineral contents of Masa are presented in table 4; 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 which help 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 are required by the body for a variety of physiological functions and the maintenance of bones 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 Olámide et al. [19] for rice-based Masa.

3.4 Sensory Attributes of Masa

The anti-nutritional contents of the Masa samples were presented in table 5; which 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 were 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. 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 reported 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 Masas. 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].
### Table 3. Proximate Composition (%) of Masa

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture</th>
<th>Protein</th>
<th>Crude fat</th>
<th>Ash</th>
<th>Fibre</th>
<th>Carbohydrate</th>
<th>Energy (kcal/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>38.46±0.11</td>
<td>5.60±0.07</td>
<td>0.71±0.02</td>
<td>0.51±0.03</td>
<td>0.61±0.06</td>
<td>54.13±0.16</td>
<td>245.25±0.18</td>
</tr>
<tr>
<td>251</td>
<td>40.64±0.42</td>
<td>14.46±1.13</td>
<td>8.49±0.04</td>
<td>1.49±0.02</td>
<td>0.79±0.01</td>
<td>34.14±0.34</td>
<td>270.77±1.55</td>
</tr>
<tr>
<td>252</td>
<td>39.77±0.30</td>
<td>12.50±0.08</td>
<td>7.59±0.03</td>
<td>2.74±0.01</td>
<td>0.79±0.06</td>
<td>36.61±0.28</td>
<td>264.75±1.21</td>
</tr>
<tr>
<td>253</td>
<td>44.48±0.22</td>
<td>15.32±0.09</td>
<td>9.71±0.04</td>
<td>3.17±0.08</td>
<td>0.62±0.04</td>
<td>26.71±0.28</td>
<td>255.47±1.21</td>
</tr>
<tr>
<td>LSD</td>
<td>0.79</td>
<td>0.88</td>
<td>0.09</td>
<td>0.12</td>
<td>0.12</td>
<td>0.76</td>
<td>3.21</td>
</tr>
</tbody>
</table>

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 beans 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

### Table 4. Vitamins and Mineral Composition of Masa

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

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
### Table 5. Anti-nutrients Contents (mg/100g) of Masa

<table>
<thead>
<tr>
<th>Samples</th>
<th>Alkaloids</th>
<th>Tannins</th>
<th>Phytate</th>
<th>Oxalate</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>0.095±0.05</td>
<td>0.535±0.02</td>
<td>0.040±0.01</td>
<td>0.015±0.01</td>
</tr>
<tr>
<td>251</td>
<td>0.145±0.01</td>
<td>0.615±0.02</td>
<td>0.060±0.00</td>
<td>0.030±0.00</td>
</tr>
<tr>
<td>252</td>
<td>1.860±0.01</td>
<td>2.600±0.04</td>
<td>1.550±0.01</td>
<td>0.285±0.01</td>
</tr>
<tr>
<td>253</td>
<td>0.345±0.01</td>
<td>1.640±0.01</td>
<td>0.270±0.06</td>
<td>0.140±0.01</td>
</tr>
<tr>
<td>LSD</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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

### Table 6. Sensory Attributes of Masa

<table>
<thead>
<tr>
<th>Samples</th>
<th>Colour</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>General Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>6.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.20&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>251</td>
<td>7.33&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>252</td>
<td>7.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>253</td>
<td>6.80&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.40&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD</td>
<td>0.68</td>
<td>1.08</td>
<td>0.86</td>
<td>1.07</td>
<td>0.77</td>
</tr>
</tbody>
</table>

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

Sensory evaluation is an important criterion for assessing quality in the development of new products and for meeting consumer requirements [37]. Colour is another 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 research highlighted that addition of African yam bean and cricket to broken rice in Masa production was observed to greatly increase 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 increased values at 20 % level of African yam bean substitution. Sensory analysis carried out in this study showed that Masa produced from sample 250 (100:0:0 % broken rice:African yam bean: cricket ) and 252 (80:20:0 Broken rice:African yam bean:cricket) 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.
DISCLAIMER

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

20. Wang S, Wakasa Y, Kawakatsu T, Takaiwa F. Increased lysine content in rice


