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Quality Evaluation of Rice-Based *Sinasir* Enriched with Plantain and Sesame Flour Blends

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ABSTRACT
Rice-based *sinasir* is naturally low in protein and micronutrients. This study evaluated the quality of *sinasir* enriched with unripe plantain (for vitamins and minerals) and sesame (for protein) by partially substituting rice flour. Five composite flour blends were formulated based on the ratio of Rice: Plantain: Sesame: RSA (100:0:0), RSB (94:5:1), RSC (88:10:2), RSD (82:15:3), and RSE (76:20:4). Functional properties, proximate composition, vitamins, and sensory attributes were analysed using one-way ANOVA at a 5% level of significance. Results showed that moisture (9.05% to 10.05%), ash (0.83% to 1.88%), fat (0.58% to 2.06%), crude protein (6.30% to 7.24%), and crude fibre (1.39% to 1.50%) increased significantly with higher substitution levels. Conversely, carbohydrate content decreased from 81.76% to 77.38%. Vitamins A and B increased with the addition of sesame and plantain, whereas vitamin C content decreased due to unit processing operations. Functional properties varied significantly across the flour samples. Sensory evaluation revealed significant differences ($p < 0.05$) in taste, colour, texture, aroma, and overall acceptability among the samples. Sample RSD (82% rice, 15% unripe plantain, 3% sesame) emerged as the most acceptable formulation. In conclusion, incorporating unripe plantain and sesame composite flour significantly enhances the nutritional profile of rice-based *sinasir* while maintaining good consumer acceptability.

Keywords: Rice-Based *Sinasir*, Quality Evaluation, Plantain, Sensory, Composition, Sesame, Overall Acceptability

INTRODUCTION

Sinasir is a yeast-fermented product which is round in shape and made from rice and other cereals such as millet and maize in West African countries. Rice-based *sinasir* is prepared using local white rice, the type used for ''*Tuwon Shinkafa"* and its procedure is similar to that of "*masa".* Though rice-based *sinasir* is similar to "*masa",* it has different method of preparation and frying. It is known as "*kisra"* in Sudan and its production varies from place to place (Ukwuru *et al.*, *2018).*

Rice (*Oryza sativa*) is a very popular cereal grain grown and consumed as a staple food in Nigeria and all over the world (Ajijola *et al.*, 2012). Rice represents 29% of the total output of grain crops worldwide and it is a major crop that grows in the standing water in vast areas of flat, low lying tropical soils. It is usually adopted for growth in tropical and sub-tropical regions of most continents and is cultivated under widely different conditions because of the great cultural diversity. Rice is an excellent source of complex carbohydrates, and it also contains little quantity of proteins, vitamins and minerals in its composition (Yadav and Jindal, 2007). There are several varieties of rice and each variety varies in their cooking and sensory characteristics, so also, Sanni *et al.*, (2005) reported that rice grown in different ecological zones varies from their properties. Each variety is quite distinct in terms of their cooking and sensory characteristics (Alaka, 2015). Interestingly, different local dishes are prepared with different types of rice that are considered suitable for such dish. Importantly, It is argued that taste, neatness, quick cooking, colour and stickiness after cooking are some of the factors that trigger consumers' preference for certain types of rice where available (Ogundele, 2014., Emodi and Madukwe, 2011). However, the choice of local rice for household and general consumption varies across different geo-political zones of Nigeria. This is associated with the different cultural and traditional food consumption pattern of the area, availability of the local rice, as well as the nutritional and psychological value attached to it (Ogundele, 2014).

Plantain (*Musa peridisiaca*) is a carbohydrate-rich food and is a good source of vitamins and minerals. It is ranked as fourth most important food crop in the world after rice, wheat, and maize and are used as beverages, fermentable sugars, medicines, flavorings and cooked foods (Philip *et al.*, 2009). Plantain occupies a strategic position for food production in Nigeria (mostly in the southern) and has been shown to be rich in dietary fibre (8.82%), resistant starch (16.2%), low in protein and fat content (Ayodele *et al.*, 2010). An average plantain has about 220 calories and is a good source of potassium and dietary fiber (Randy *et al.*, 2007). They contain antioxidants that fight free radicals with good levels of vitamin c and protein, and they can also support the immune function. Likewise, their vitamin B6 content may prevent and reduce the risk of cardiovascular diseases and improve mood, boost, metabolism and burns fat, prevent constipation generally slows the release of glucose (Okolle *et al.*, 2009, Okolle *et al.*, 2018).

Sesame *(Sesamum indicum Linn.*) commonly known as beniseed is a tropical annual crop and one of the oldest oilseeds cultivated in the world (Gharbia *et al*., 2000). *Sesamum indicum L.* in the world production of edible oil seeds, ranks eight (National Agricultural Extension and Research Liaison Services (NEARLS), 2010. According to Raw materials Research and development Sector [RMRDC] 2004, twenty five percent (25%) of the world Sesame is grown in Africa with Sudan, Uganda and the leading producer Nigeria and it is mostly produced either for food and oil or in generating revenues to the government both locally and internationally. Sesame contains carbohydrate, fat/oil, protein, moisture, crude fiber and ash (Nwobasi and Attamah, 2017). Falusi, (2008), stated that its oil contains natural antioxidants that gives stability and long shelf.

Rice-based sinasir tends to be low in protein, minerals and vitamins since it's made from rice alone, and there is a high tendency of nutrient deficiency problems as its consumption becomes more and more popular among people and meeting consumers' daily dietary needs. There is little information on rice-based sinasir which is a cereal based food product containing mainly carbohydrate and none on its enrichment with blends of other materials such as plantain and sesame to improve its nutritional value and providing information on the composition of protein, mineral and vitamin content. Absence or insufficiency of these vital nutrients could result in protein deficiency problems such as kwashiorkor (manifested as edema and liver enlargement) and stunted growth in children, and marasmus, vitamins and minerals deficiency diseases such as scurvy rickets, beri-beri, pellagra, and vitamin k and iron deficiency diseases. Therefore, this study was carried out to improve the nutritional quality of rice-based *sinasir*.

MATERIALS AND METHODS

Source of Material

Rice, unripe matured green plantain and sesame were purchased from Yankura Market Kano State along with other ingredients such as yeast, sugar, salt and vegetable oil.

Methods

The recipe and procedure for the preparation of rice-based *sinasir* flour samples was made by carefully preparing and sorting before commencing production, and various portions of rice flour with plantain flour and sesame flour was substituted at various levels as formulations. The Figures and flow charts below show the production the rice, plantain and sesame flour, and that of rice-based *sinasir*.

Preparation of Rice Flour

The rice grains were cleaned by sorting and washing to remove stones and other unwanted materials from the rice grains. The rice was partially shade-dried and milled to a fine consistency with the aid of a milling machine. The rice flour was then sieved to obtain a fine flour and spread in a clean tray and allowed to air-dry completely.

Production of Plantain Flour

In production of unripe plantain flour, undamaged unripe plantains were selected and separated into individual fingers, washed andpeeled by hand and the pulps were cut, and sliced into thin discs. The sliced plantain was further blanched at about 80°C for 3-5minutes and laid out on a tray with some air space between them and it was allowed to dry completely. When fully dried, the chips were then milled and sieved to obtain a fine flour.

Preparation of Sesame Flour

Sesame seeds were sorted to remove sticks, light particles, stones and other contaminants. The seeds were de-hulled and allowed to air-dry in a shade after which it was roasted/blanched at 60°C. It was then drained and dried. The result obtained was milled and sieved to produce the sesame seed flour.

Production of Sinasir

Flours obtained from rice grain, unripe plantain, and sesame were weighed accurately and mixed to create 100g samples, each was labelled following the experimental formulations established in Table 1... Little salt (1/8 teaspoonful or grams), 5grams of sugar and leavening agent (about 1tablespoon or 0.5gram of active dry yeast (*saccharomyces cerevisiae*) was added. Water was added to each of the flour blend (of rice, plantain and sesame) to make thick slurries in a clean bowl after which it was mixed properly and then allowed to set. The slurry was then allowed to stand and ferment (rise) for about 45-50minutes. Half (1/8 or 0.5gram) tablespoon of baking powder was added and the slurry stirred. After that, the pan was heated and brushed with a little quantity of vegetable oil and half cup of the slurry (about 120ml) added to the pan and covered with the lid of the pan, and is toasted one side under low heat for 1-2minute (slightly brown crust was observed on the toasted side). It was transferred to a clean place/plate. The slurry was stirred again, pan heated and coated and the cycle was repeated until no slurry is left.

Table 1: Flour Formulation for *Sinasir*

Parameters	Rice (%)	Plantain (%)	Sesame (%)
Sample RSA	100	0	0
Sample RSB	94	5	1
Sample RSC	88	10	2
Sample RSD	82	15	3
Sample RSE	76	20	4

Keys:
RSA: Rice Flour 100%, Plantain Flour 0%, and Sesame Flour 0%.
RSB: Rice Flour 96%, Plantain Flour 5%, and Sesame Flour 1%.
RSC: Rice Flour 88%, Plantain Flour 10%, and Sesame Flour 2%.
RSD: Rice Flour 82%, Plantain Flour 15%, and Sesame Flour 3%.
RSE: Rice Flour 76%, Plantain Flour 20%, and Sesame Flour 4%.

Table 2: Ingredient for Production of *Sinasir* (100g flour)

Materials	Quantity (g)
Granulated Sugar	6g
Groundnut Oil	1g
Salt	0.5g
Yeast	0.5g
Baking powder	0.5g
water	240ml (1cup)

Proximate Composition

This involves the moisture content determination, determination of ash content, determination of crude protein, determination of fat content and carbohydrate content. The proximate composition of the formulated flour blends was evaluated according to Association of Official Analytical Chemists (A.O.A.C., 2012).

Determination of Moisture Content

Five grams of each sample were weighed into a dry crucible. The crucibles containing the weighed samples were placed in a moisture extraction oven at 105°C for 3 hours. The dried sample was allowed to cool in a desiccator after which it was weighed. The process was repeated until constant weight was obtained. The difference in weight was calculated as a percentage of the original sample i.e. loss in weight multiplied by 100 over the original weight of sample and the experiment was replicated two more times. The mean was taken as the percentage moisture content.

$$\text{Moisture content (\%)} = \frac{\text{W2} - \text{W3}}{W2 - W1} X \frac{100}{1}$$

Where;
W1=initial weight of crucible.
W2= weight of crucible + undried sample
W3= weight of crucible + dried sample

Protein Content Determination

Total protein was determined by the kjeldahl method. The analysis of a compound of its protein content by the kjeldahl method was based on the determination of the amount of nitrogen present. Five (5) grams of each sample was carefully weighed using digital weighing balance and transferred into the kjeldahl flask containing coiling clips. A mixture of copper and sodium sulphate (1 g each) was added using a spatula to help raise the temperature of boiling. Twenty (20) millimetres of concentrated H_2SO_4 was added to the flask to aid digestion. The mixture was digested (heated) in a fume cupboard until the solution turned colourless. It was then cooled to room temperature and transferred quantitatively into 100ml volumetric flask and the digest made up to mark with water. Twenty (20) millilitres of the digest was pipetted and transferred to the distillation flask. Ten (10) millilitres of 2% Boric acid was measured out into a small beaker (receiver) and two drops of methyl red indicator was added to it. Thirty-five (35) millilitres of 40% NaOH was added to the distillation flask and the plug was quickly replaced. The mixture was distilled and the distillate collected into the boric acid solution. The distillate was then collected and titrated against a standard 0.1N HCL until the solution turned colourless. A reagent blank was also digested, distilled and titrated. The experiment was done in triplicate and the average value was taken.

The percentage nitrogen was calculated and multiplied with a factor of 6.25 to obtain the crude protein content, i.e.

$$\%\,\text{Nitrogen} = (\text{T} - \text{B})\frac{(100 \times \text{N} \times 14 \times \text{Va})}{100 \times Va}$$

Crude protein = % Nitrogen × 6.25.
Where:
N = Normality of the titrate (HCL =0.1 N)
Vf= Total volume of digest (100ml).
T = Titre value of sample
B = Blank titre value.
Va = Aliquot volume distilled

Fat Content Determination (Soxhlet Method)

Five (5) grams of each was carefully place in a fat free thimble. This was covered with cotton wool to avoid loss of sample. The loaded thimble was put in the Soxhlet extractor. Two hundred (200ml) millilitres of petroleum ether was poured into a weighed fat Soxhlet flask and the flask was then attached to the extractor. The flask was placed on a heating mantle so the petroleum ether in the flask refluxed. Cooking and condensation were achieved by a running tap water connected to the extractor for at least 6 hours after which the solvent was completely siphoned into the flask. Rotary vacuum evaporator was used to evaporate the solvent leaving behind the extracted lipids in the Soxhlet flask. The flask was removed from the evaporator and dried to a constant weight in the oven at 60°c. The flask was then cooled in a desiccator and weighed. Each determination was done in triplicate. The amount of fat extracted was calculated using the formula below;

$$\%\,\text{Fat} = \frac{(\text{weight of extracted lipid})}{weight\ of\ sample}\ X\ \frac{100}{1}$$

Determination of Crude Fibre Using A.O.A.C. (2012) Acid Alkali Digestion (Weende) Method

Five (5) grams of each sample and 1/g asbestos was put into 200/ml of 1.25% of H_2SO_4 and boiled for 30 minutes under reflux and the boiled samples was washed with hot water. The solution and the content were then poured into Buchner funnel equipped with muslin cloth and secure with elastic band. The solution was allowed to filter and the residue was put into 200/ml boiling NaOH which was allowed to boil for 30 minutes before being transfer to the Buchner funnel where it was filtered. It was washed again twice with alcohol. The material obtained was washed thrice with petroleum ether. The resulting residue was put in a clean dry crucible and it was dried in the moisture extraction oven to a constant weight. The dried crucible was then removed, cooled and weighed. The residue was later incinerated in a muffle furnace at 600/°c for 2 to 3 hours and allowed to cool in a desiccator and weighed. Each determination was done in duplicate.

$$\%\,\text{Crude Fibre} = \frac{\text{w1} - \text{w2}}{w3} \times 100$$

Where;
W1= weight of sample before incineration
W2 = weight of sample after incineration
W3 =weight of original sample

Determination of Ash Content

Five (5) grams of each of the formulated flour blends was weighed using analytical balance into a crucible then heat in a moisture extraction oven (model; Uniscope 9053 Laboratory Oven) for 3 hours at 100/°c. Then the sample was transferred into a muffle furnace set at 550°C until turns white and free of carbon. The sample was then removed from the furnace, cooled in a desiccator to room temperature and reweighed completely. The experiment was done in duplicate and the mean taken. The weight of the residual ash was then calculated as ash content

$$\%\,\text{Ash} = \frac{(\text{weight of ash})}{weight\ of\ original\ sample} \times 100$$

Carbohydrate Determination

The percentage of carbohydrate or nitrogen free extract was calculated as the difference between 100% and the summation of percentages of the other measured parameters.
Carbohydrate = 100 + (A + B + C + D + E)

Where; A, B, C, D and E are percentages of moisture, protein, fat, ash, and crude fibre

Determination of Vitamin Content

Determination of Vitamin A

The AOAC (2010) method was adopted using the calorimeter. This measures the unstable colour at the absorbance of 620nm that results from the reaction between vitamin A and SbL_3. Pyrogallol (anti-oxidant) was added to two grams of sample prior to saponification with 200 ml alcoholic KOH. The saponification is expected to take place in water bath for 30 minutes. The solution was transferred to a separating funnel where water was added. The solution was extracted with 1 - 2.5 ml of hexane. The extraction was washed with equal volume of water. The extract was filtered through filter paper containing 5 g anhydrous Na_2SO_4 into volumetric flask. The filter paper was rinsed with hexane and made up to 25mL volume of the filtered hexane extract containing the isolated Vitamin A, measured precisely within a 25 mL volumetric flask. The hexane was evaporated from the solution and blank. About 1 ml chloroform and SbL_3 solution was added to the extract and blank. The reading of the solution and blank was taken from the colorimeter adjusted to zero absorbance or 100 %.

Calculation:

$$\text{Vitamin A} = \text{A620 nm} \times \text{SL} \times (V/_{w_t})\text{Mg}$$

Where, A620 nm= Absorbance at 620 nm
SL= Slope of standard curve (vitamin A concentration) + A620 reading
V= Final volume in colorimeter tube
Wt= Weight of sample

Determination of Vitamin B

Thiamine was determined by using AOAC (2010) procedure. Five grams of each sample was homogenized in 5 ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up of 100 ml with the extract solution. Ten millilitres (10 ml) aliquot of the extract was dispensed into a flask and 10 ml of potassium dichromate solution was added. The resultant solution was incubated for 15 minutes at room temperature (25 ± 1°C). The absorption was read from the spectrophotometer at 420nm using a reagent blank to standardize the instrument at zero. The vitamin content was calculated as follows:

$$\text{Thiamine } {}^{\text{mg}}/_{100g} = \frac{100}{W} \times \frac{\text{au}}{as} \times \text{C} \times \text{d}$$

Where, W= Weight of sample analyzed
au = Absorbance of the sample solution
as =Absorbance of standard solution
C = Concentration of standard solution
d= Dilution factor.

Determination of Vitamin C

The AOAC (2010) method of using 2,6 dichlorophenol titrimetric method was used. Two grams (2 g) of the formulated samples of each flour blend were extracted by homogenizing sample in acetic acid solution. The standard solution was prepared by dissolving 50 mg standard ascorbic acid tablet in 100 ml in a volumetric flask with water. The solution was filtered to get clear solution. Ten millilitre (10 ml) of the filtrate was added into a flask in which 2.5 ml acetone is added. This was titrated with indophenols solution (dye 2.6, dichlorophenol indophenols) to a faint pink colour which persists for 115 seconds. The standard was treated identically.

$$\text{Mg Ascorbic acid 1g} = \text{C} \times \text{V} \times \frac{\text{DF}}{\text{WT}}$$

Where, C= mg ascorbic acid 1ml dye
V= Volume of dye used for titrate of diluted sample
DF= Dilution factor
WT= Weight of sample in g.
Source: A.O.A.C. (2010)

Determination of Mineral Content

Calcium (Ca) and Magnesium (Mg) levels were determined using the Atomic Absorption spectrophotometer (2010 VGP model). Sodium (Na) and potassium (K) Levels were determined using flame photometric method while phosphorus (P) level was determined by using calorimetric method. (Ulla M. *et al., 2015*).

Determination of Calcium (Ca)

Three (3) mls of the sample was pipetted into a test tube in triplicate. Then 5 mls of calcium working reagent was added and absorbance at 512 nm was read against the blank.

Determination of Potassium (K)

Five (5) mls of the sample was pipetted into a test tube in triplicate. Then two (2) mls of colbalnitrate was added, then shaken vigorously and allowed to stand for 45 minutes and centrifuge for 15 minutes. The supernatant was then drained off and 2mls of distilled water was added to the residue. The solution was then boiled for 10 minutes with frequent shaking to dissolve the precipitate. One (1) ml of 1% choline hydrochloride and 1ml of 2% sodium ferric cyanide was then added. Then Two (2) ml) of distilled water was also added and then the solution was shaken to mix well. The absorbance was taken at 620 nm against the blank.

Determination of Magnesium (Mg)

Five (5) mls of the sample digest of the formulated flour blends was pipetted into a test tube in duplicate. Then one (1) ml of 0.67N sulphuric acid (H_2SO_4) was added, 1 ml of 0.05%titan yellow was added also. Then 1 ml of 0.01% gum acacia was added and 2 mls of the 10% sodium hydroxide (NaOH) was also added. The solution was mixed together and the absorbance taken at 520 nm against the blank.

Determination of Sodium (Na)

Five (5) ml of the sample was pipetted into a test tube in triplicate of which five (5) mls of ammonia was also added. From this mixture, metals were extracted by adding consecutively, 5ml portions of ditizone extraction solution 1 until ditizone became green after extraction. Time per extraction was noted and after each addition of the 5 ml of ditizone extraction solution 1, the upper was transferred to another dry test tube. After the extraction, the supernatant was separated from the residue. . The supernatant was discarded while the residue was allowed to settle and centrifuge for 15 minutes. The absorbance was then taken at 520nm against the blank. The concentration of each of the element was calculated using the formula;

$$\%\text{C or } \%\text{ K or } \%\text{ Na} = \frac{(\text{meter reading (MR)} \times slope \times dilution\ factor)}{1000}$$

Source: A.O.A.C. (2012)

Determination of Phosphorus (P)

The phosphorus in the sample will be determined by molybdate vanadate calorimetric method. A measured volume of the volume of the dry ash (2mg) digest of the sample was dispersed into a 50 ml volume flask. At the same time, the same volume of distilled water and standard P solution will be measured into different flask to serve as reagent blank and standard respectively. Two (2) mls of the phosphorus colour reagent (molybdovanadate solution) was added to each of the flask and allowed to stand at room temperature for 15 minutes. The content of each flask was then diluted to the 50 ml mark with distilled water and its absorbance was measured in a spectrophotometer at a wavelength of 540m with the reagent blank at zero. The phosphorus content was calculated using the formula below:

$$\mathrm{P}\ {}^{\mathrm{mg}}/_{100g} = \frac{100}{W} \times \frac{\mathrm{au}}{as} \times \mathrm{C} \times \frac{\mathrm{VT}}{Va}$$

Where: w = weight of sample
Au= absorbance of test sample
As= absorbance of standard phosphorus solution
C = concentration of standard phosphorus solution
Vt= total extract volume
Va= volume of extract analyzed
Source: A.O.A.C. (2012)

Determination of Functional Properties

The functional properties of composite flour (rice, plantain and sesame) were determined by the method described by Onwuka (2005). Parameters such as bulk density, water/oil absorptivity and swelling power were determined.

Bulk Density

One Hundred (100g) grams of the flour sample was poured into a 50 ml graduated measuring cylinder. It was gently tap on the bench until a constant volume was noticed. And base on the weight and volume the apparent bulk density was calculated. The volume of the sample was recorded.

$$\text{The bulk density} = x = \frac{\text{weight of sample } (g)}{Volume\ of\ same\ sample\ (ml)}$$

Source: A.O.A.C. (2012)

Determination of Water Absorption Capacity

Five (5) grams of the flour sample was weighed into 15ml centrifuge tube and it was suspended in water. It was then shaken on a platform tube rocker for a minute at room temperature, and sample was then allowed to stand for 30minutes and it was centrifuged at 300/rpm for 30/minutes. The volume of free water from the centrifuge tube was read. Water absorption capacity was examined as percent bound per gram flour. Calculation: water absorption of the sample was calculated as:

$$(Total\ water\ absorbed - Free\ water) X\ Density\ of\ water$$

Swelling Index

Five (5g) grams of each of the formulated flour blends was weighed into 100 ml of graduated cylinder. Exactly 50 mls of distilled water was added and the top of the graduated cylinder was tightly covered and mixed by inverting the cylinder, the suspension was inverted again after 2 minutes and left to stand for further 8/minutes. The volume occupied by the sample was taken after 8 minutes.

$$\text{Swelling power} = \frac{(\mathrm{W2}) - (\mathrm{W1})}{Weight\ of\ sample}$$

Where W1= volume occupied by sample
W2= volume of sample after inversion
Source: Onwuka (2005)

Oil Absorption Capacity (Oac)

Five (5) grams of the sample was mixed with 10 ml of refined ground nut oil in a centrifuge tube and was allowed to stand at room temperature (30 ± 2°C) for 1hr. it was centrifuged at 2000 rpm for 20mins. The volume of the free oil was recorded and decanted. Fat adsorption capacity was expressed as percentage of oil bound by 100gms of dried flour.

$$\text{Weight \%} = \frac{\text{Volume of absorbed}}{Weight\ of\ sample} \times \frac{100}{1}$$

Source: Onwuka (2005)

Sensory Analysis

Sensory analysis was run to evaluate (rice-based) enriched *sinasir*. Sensory evaluation is a scientific discipline used to analyze, evoke and interpret reaction to those characteristics of food and materials as they are perceived by the sense of smell, sight, taste, texture and touch. This was used to evaluate the general acceptability of the various compositions of *sinasir* (rice pancake). Attributes such as taste, colour, texture, aroma and overall acceptability of the *sinasir* produced from the samples of the formulated flour blends were evaluated. The sensory scores were subjected to the nine-point hedonic scale of the following rating;

9– Liked extremely;
8 – Liked very much;
7– Liked moderately;
6– Liked slightly;
5– Neither liked nor disliked;
4– Disliked slightly;
3– Disliked moderately;
2 – Disliked very much; and
1 – Disliked extremely

Statistical Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) version 21.0 computer package at 5% level of significance.

Data from both chemical analysis and sensory evaluation were subjected to one-way Analysis of Variance (ANOVA), with results expressed as means and standard deviations. Where significant differences occurred in the chemical parameters, means were separated using Duncan's Multiple Range Test (DMRT). Statistical significance was established at \(p < 0.05\), and differing superscripts within the same column denote significantly different values.

RESULTS AND DISCUSSION

Proximate Analysis

Table 3 shows the proximate composition of the flour samples used for the production of *sinasir*. According to the result shown, there is no significance difference in the moisture content of sample RSB and sample RSC, so also between sample RSD and sample RSE, but sample RSA is significantly different from all of them. For the moisture content, values range from 9.05, 9.47, 9.50, 10.16 and 10.05 for the sample RSA, RSB, RSC, RSD and RSE respectively. The moisture content varies with sample. The sample with the highest moisture content is RSE, while RSA has the lowest. The relative low moisture content is an indication of storage stability of the flour samples.

The ash content indicates no significant difference in sample RSC, RSD and RSE with values 1.82, 1.83 and 1.88. However, there was significant difference in sample RSA and the others, so also in sample RSB and the others with values of 0.83.and 1.41 respectively. Sample RSA had the lowest ash content, while sample RSE had the highest ash content. The ash content of a food sample gives an idea of the mineral elements present in the food. It indicates the composition of inorganic constituents after organic materials (fats, protein and carbohydrates) and moisture have been removed by incineration, it is essentially the mineral content of a sample.

For the fat content, results obtained for sample RSA, RSB, RSC, RSD and RSE are 0.58, 0.86, 1.19, 1.87 and 2.06 respectively. The results ranges from 0.58 to 2.06; this may be due to the fact that cereals, legumes and tubers stores energy in the form of starch rather than lipids. There is significant difference between the fat content of all the samples at 5% probability level and sample RSA (0.58) tends to be the least, while sample RSE (2.06) the highest in fat content.

The protein content of blends increased with increase in sesame flour. There is no significant difference between the crude protein content of sample RSA and RSB having values of 6.30% and6.35% respectively. The protein tends to increase down the sequence at 5% level of probability. Protein content of sample RSA and RSB are significantly different from that of sample RSC (6.68%), RSD (6.92%) and RSE (7.24%). Yadav and Jindal, 2007 in their study stated that rice contains little protein. Sample RSE has the highest crude protein content while sample RSA has the lowest crude protein content. This increase was expected, as sesame flour contains a higher protein content than both rice and plantain flour. This is in agreement with Bamigboye, *et al.,* 2010, who stated that rice may be low in protein and essential minerals and therefore may require substitution with other materials rich in those nutrients it lacking.

Table 3: Proximate Analysis

Samples	Moisture (%)	Ash (%)	Fat (%)	Crude Protein (%)	Crude Fibre (%)	Total Carbohydrate (%)
RSA	9.05 ± 0.07^{a}	0.83 ± 0.04^{a}	0.58 ± 0.01^{a}	6.30 ± 0.00^{a}	1.50 ± 0.01^{ab}	81.76 ± 0.04^{d}
RSB	9.47 ± 0.01^{b}	1.41 ± 0.12^{b}	0.86 ± 0.00^{b}	6.35 ± 0.01^{a}	1.48 ± 0.09^{a}	80.43 ± 0.13^{c}
RSC	9.50 ± 0.01^{b}	1.82 ± 0.02^{c}	1.19 ± 0.03^{c}	6.68 ± 0.04^{b}	1.45 ± 0.01^{a}	79.36 ± 0.09^{b}
RSD	10.16 ± 0.21^{c}	1.83 ± 0.01^{c}	1.87 ± 0.02^{d}	6.92 ± 0.00^{c}	1.44 ± 0.01^{a}	77.79 ± 0.45^{a}
RSE	10.05 ± 0.06^{c}	1.88 ± 0.01^{c}	2.06 ± 0.01^{e}	7.24 ± 0.02^{d}	1.39 ± 0.00^{a}	77.38 ± 0.47^{a}

Values are Mean ± Standard Deviation of Replicate Analysis. Values with Different Superscripts Down the Column are Significant (P<0.05) Different.

Keys:
RSA: Rice Flour 100%, Plantain Flour 0%, and Sesame Flour 0%.
RSB: Rice Flour 96%, Plantain Flour 5%, and Sesame Flour 1%.
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RSD: Rice Flour 82%, Plantain Flour 15%, and Sesame Flour 3%.
RSE: Rice Flour 76%, Plantain Flour 20%, and Sesame Flour 4%.

The result indicates that the crude fibre content of all the samples, RSA, RSB, RSC, RSD and RSE decreases sequentially with values 1.50, 1.48, 1.45, 1.44 and 1.39 ($p > 0.05$). but sample RSA significantly different from the other samples. Sample RSA has the highest crude fibre content while sample RSE has the smallest crude fibre content. The crude fibre content decreases with increase in plantain and sesame substitution.

The table shows that the carbohydrate content decreased down the sequence from sample RSA to sample RSE. Carbohydrate content tends to be highest at 81.76 for sample RSA, and lowest in sample RSE 77.38. The table also indicates that there is significant difference between the carbohydrate content in all samples at 5% probability level but sample RSD and RSE are not significantly different. Increasing the level of substitution progressively reduced the rice flour content of the blend. Because rice is a superior source of complex carbohydrates compared to unripe plantain (Yadav and Jindal, 2007), this reduction consequently led to a decrease in the overall carbohydrate content of the final product. The increase in the protein content of the flours down the sequence could be attributed to the plantain (which is high in lipid, protein, carbohydrate, and mineral content) in the samples, and the result is in agreement with Bamigboye, *et al,* 2010.

Vitamin Content in Samples

Table 4 shows the vitamin content of flour samples used in the production of rice-based *sinasir* which comprises of rice flour, plantain flour and sesame flour blends. For the vitamin A, content ranged from 0.004±0.000 for sample RSA which is the lowest up to 0.124 which is the highest. And the result indicates that there is significance difference between the vitamin A content of the sample RSA, RSB, RSC, RSD and RSE.

The vitamin B content for the composite flour blends tends to increase down the sequence as the proportions of substitutions increase. Sample RSA had the lowest vitamin B content of 0.031 and sample RSE the highest of about 0.124. The vitamin B content differed significantly among the flour blends (samples RSA to RSE) at a 5% probability level, with the sole exception of samples RSB and RSC, which exhibited no significant difference between them.

The table also indicates that there is significant difference between the vitamin C content of the flour samples ranging from sample RSA 0.014 to sample RSE 0.003 at 5%level of probability except for sample RSD and RSE which are not significantly different. The vitamin C content decreased progressively with increasing levels of substitution. This decline is directly related to the reduced proportion of rice in the formulations. Although unripe plantain is typically an excellent source of vitamin C, its expected contribution was likely compromised during processing. Because vitamin C is highly water-soluble and heat-sensitive, it easily degrades when subjected to washing, blanching, and elevated cooking temperatures (Olubukola *et al.,* 2010; Monica *et al,* 2021). Also, Yadav and Jindal 2007 states that rice contains little vitamins.

Table 4: Vitamins

Samples	Vitamin A (mg/100g)	Vitamin B (mg/100g)	Vitamin C (mg/100g)
RSA	0.004 ± 0.000^{a}	0.031 ± 0.001^{a}	0.014 ± 0.000^{d}
RSB	0.006 ± 0.000^{b}	0.097 ± 0.000^{b}	0.009 ± 0.000^{c}
RSC	0.0164 ± 0.000^{c}	0.097 ± 0.001^{b}	0.006 ± 0.000^{b}
RSD	0.018 ± 0.000^{d}	0.114 ± 0.000^{c}	0.003 ± 0.000^{a}

RSE	0.020 ± 0.000[e]	0.124 ± 0.000[d]	0.003 ± 0.000[a]

Values are Mean ± Standard Deviation of Replicate Analysis. Values with Different Superscripts Down the Column are Significant (P<0.05) Different.

Keys:
Sample RSA: Rice flour 100%, Plantain flour 0%, and Sesame flour 0%
Sample RSB: Rice flour 96%, Plantain flour 5%, and Sesame flour 1%
Sample RSC: Rice flour 88%, Plantain flour 10%, and Sesame flour 2%
Sample RSD: Rice flour 82%, Plantain flour 15%, and Sesame flour 3%
Sample RSE: Rice flour 76%, Plantain flour 20%, and Sesame flour 4%.

Mineral Content in Samples
Table 5 shows the mineral content of flour samples. At 5% probability level, there is no significant difference between the amount of phosphorus content of flour sample RSA and RSB. There is no significant difference between the phosphorus content of sample RSC and RSD. There is no significant difference between that in sample RSD and RSE, but sample RSC and RSE are significantly different. The mineral (phosphorus) content of samples tend to increase down the sequence with increase in levels of substitutions of plantain and sesame from sample RSA to RSE. The result also indicates that amount of phosphorus is highest in sample RSE (23.95) than in sample RSA (20.32). Minerals are a group of essential nutrients which serves a variety of important metabolic functions and are a part of molecules such as haemoglobin, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA)

For the calcium content as indicated from the table below, tends to increase down the sequence as the amount of substitution increases. Calcium content was found to be highest in sample RSE (19.86mg) compared to the 7.72mg from sample RSA. There is significant difference between calcium content of the flour samples except for sample RSA (7.72) and RSB (7.99) which are not significantly different.

There is significance difference between the potassium content of the flour samples of *sinasir*. The amount of potassium tends to increase down the sequence ranging from sample RSA, RSB, RSC, RSD and RSE which are 36.80, 50.73, 71.66, 90.93 and104.38 respectively.

The amount of magnesium tends to increase down the sequence ranging from sample RSA, RSB, RSC, RSD and RSE which are 14.06, 15.80, 17.30, 18.66 and19.68 respectively There is significance difference between the magnesium content of the flour samples of *sinasir* at 5% probability level. Sample RSE has the highest amount of magnesium of 194.06 while sample RSA has the lowest of 14.06. The increase in magnesium content maybe due to the increase in proportion of the sesame in the composite flour lends.

Table 5: Minerals

Samples	P (mg/100g)	Ca (mg/100g)	K (mg/100g)	M (mg/100g)	Na (mg/100g)
RSA	20.32 ± 0.01[a]	7.72 ± 0.35[a]	36.80 ± 0.02[a]	14.06 ± 0.09[a]	11.57 ± 0.05[a]
RSB	20.79 ± 0.62[a]	7.99 ± 0.64[a]	50.73 ± 0.31[b]	15.80 ± 0.26[b]	11.96 ± 0.21[b]
RSC	23.15 ± 0.04[b]	12.36 ± 0.21[b]	71.66 ± 0.04[c]	17.30 ± 0.04[c]	12.35 ± 0.03[c]
RSD	23.82 ± 0.01[bc]	18.21 ± 0.13[c]	90.93 ± 0.69[d]	18.66 ± 0.03[d]	12.57 ± 0.08[c]
RSE	23.95 ± 0.06[c]	19.86 ± 0.06[d]	104.38 ± 0.80[e]	19.68 ± 0.40[e]	12.65 ± 0.19[c]

Values are mean ± standard deviation of replicate analysis.; Values with different superscripts down the column are significant (P<0.05) different

Keys:
Sample RSA: Rice flour 100%, Plantain flour 0%, and Sesame flour 0%
Sample RSB: Rice flour 96%, Plantain flour 5%, and Sesame flour 1%
Sample RSC: Rice flour 88%, Plantain flour 10%, and Sesame flour 2%
Sample RSD: Rice flour 82%, Plantain flour 15%, and Sesame flour 3%
Sample RSE: Rice flour 76%, Plantain flour 20%, and Sesame flour 4%.

According to the result above, there was increase in the sodium content the flours from sample RSA to RSE, that is, 11.57 to 12.65 respectively. The table also indicates that there is significant difference between the amount of sodium in the flour samples except for sample RSC, RSD and RSE. This result is in agreement with Yadav and Jindal 2007.

Physical and Functional Properties
Table 6 shows the physical and functional properties of flour samples used for production of rice-based *sinasir* plantain and sesame flour composition.

The swelling index (g/ml) tends to increase with increase in the proportion of plantain and sesame flour blends ranging from 0.49, 0.55, 0.59, 0.63 and 0.65 for sample RSA, RSB, RSC, RSD and RSE respectively. At 5% probability level, there is no significant difference between the flour samples of sample RSA, RSB and RSC, and there is also significant difference between swelling index of flour samples of sample RSB, RSC, RSD and RSE, but there is significant difference the swelling index of between sample RSA, At a 5% probability level, no significant difference was observed among the swelling indices of flour samples RSA, RSB, and RSC. However, significant variations occurred when comparing these to samples RSD and RSE. Furthermore, the swelling indices of samples RSD and RSE differed significantly from each other and from the remaining formulations ($p < 0.05$). RSD and RSE. Sample RSA has the lowest swelling index, while sample RSE has the highest.

There is no significant difference between bulk densities of the flour samples used for production of the enriched rice-based *sinasir*. There is increase in the bulk density of flour samples with increase in the substitution levels of unripe plantain ans sesame flour progressively from samples RSA, RSB, RSC, RSD and RSE with values 0.61, 0.76, 0.77, 0.80 and 0.80 respectively. The bulk densities indicate the porosity of a product which influences the packaging design and could be used in determining the type of packaging material required (Iwe and Onadipe, 2001). The table shows that the bulk density of sample RSE is the highest and lowest at sample RSA.

There is no significant difference between the water holding capacity of sample RSA, RSB, RSC and RSD, and also, there is no significant difference in that of sample RSB, RSC, RSD, and RSE, but there is a significant difference between the water holding capacity of sample RSA and RSE. The observed variation in water holding capacities between flour samples may be attributed to their different protein concentrations and their degree of interaction with water and their conformational characteristics (McWaters *et al*, 2003). It is a measure of amylose and amylopectin in the starch granules and weaker associative forces maintaining the granular structure. It is the measure of the amount of water that can be absorbed per gram of sample. The table indicates that Water Holding Capacity for samples increased down the sequence from sample RSA to RSE (1.61, 2.03, 2.20, 2.41 and 2.56). Sample RSE happens to have the lowest water holding capacity of 1.61ml/g while Sample RSD has the highest water holding capacity of 2.56ml/g.

Table 6 further indicates that oil holding capacity for samples increased down the sequence from sample RSA to RSE (RSA, RSB, RSC, RSD and RSE with values 1.50, 2.25, 2.45, 2.50 and 2.50 respectively) and decreased for sample RSE (2.45). The oil holding capacity is an important functional property that enhances the mouth feel while retaining the flavour of food products (Adebowale *et al.*, 2005). The table also shows that sample RSD and RSE has highest oil holding capacity while sample RSA has the least oil holding capacity. There is no significant difference between the oil holding capacity of sample RSB, RSC, RSD and RSE, but there is a significant difference between the oil holding capacity of sample RSA and the other samples (i.e. sample RSB, RSC, RSD and RSE). Absorption of oil by food products improves the mouth feel, flavour retention, and this makes it an important property in such food formulations.

Table 6: Functional Properties

Samples	Swelling index (ml/g)	Bulk density (g/ml)	Water Holding (ml/g)	Oil Holding Capacity(ml/g)
RSA	0.49 ± 0.01^{a}	0.61 ± 0.23^{a}	1.61 ± 0.06^{a}	1.50 ± 0.00^{a}
RSB	0.55 ± 0.07^{ab}	0.76 ± 0.14^{a}	2.03 ± 0.24^{ab}	2.25 ± 0.35^{b}
RSC	0.59 ± 0.01^{ab}	0.80 ± 0.00^{a}	2.20 ± 0.01^{ab}	2.45 ± 0.07^{b}
RSD	0.63 ± 0.04^{b}	0.77 ± 0.01^{a}	2.41 ± 0.33^{ab}	2.50 ± 0.00^{b}
RSE	0.65 ± 0.07^{b}	0.80 ± 0.00^{a}	2.56 ± 0.55^{b}	2.50 ± 0.00^{b}

Values are mean ± standard deviation of replicate analysis.
Values with different superscripts down the column are significant ($P<0.05$) different.
Keys:
Sample RSA: Rice flour 100%, Plantain flour 0%, and Sesame flour 0%
Sample RSB: Rice flour 96%, Plantain flour 5%, and Sesame flour 1%
Sample RSC: Rice flour 88%, Plantain flour 10%, and Sesame flour 2%
Sample RSD: Rice flour 82%, Plantain flour 15%, and Sesame flour 3%
Sample RSE: Rice flour 76%, Plantain flour 20%, and Sesame flour 4%

Sensory Evaluation of samples

Table 7 shows the results of the sensory attributes of rice based *sinasir* made from the flour blends of rice, plantain and sesame flour scored as well as their general acceptability.

Aroma

The aroma for sample RSD is most preferred after which is sample RSE. Sample RSA and RSB were the least and are not significantly different in their aroma (6.80 ± 1.67 and 6.80 ± 1.28 respectively), but they are significantly different from that of sample RSC, RSD, and RSE respectively. As indicated in the table, the scores for aroma are 6.80±1.67, 6.80±1.28, 6.90±1.29, 7.75±0.85, 7.60±0.88 for samples RSA, RSB, RSC, RSD and RSE. Sample RSD aroma tends to be the most preferred with the score 7.75±0.85.

Taste

For the taste, sample RSD and RSE are most liked than that of sample RSA, RSB and RSC. The scores as indicated in the table are 6.65±1.39, 6.65±1.30, 6.65±0.99, 7.45±1.23 and 7.45±0.69 for sample RSA, RSB, RSC, RSD and RSE. Sample RSA, RSB and RSC are not significantly different, so also sample RSD is not significantly different from sample RSE, but the taste for sample RSA RSB and RSC are significantly different from sample RSD and RSE.

Mouth feel

The mouth feel for the five samples are significantly different except for sample RSA and RSC which are not significantly different from each other. Sample RSD is most preferred while that of sample RSA is the least. The scores as indicated in the table are 6.60±1.76, 6.85±1.50, 6.75±1.07, 7.75±1.02 and 7.50±0.83 for sample RSA, RSB, RSC, RSD and RSE.

Colour

For colour, sample RSE is most preferred than the others. The colour of sample RSC is the least preferred. The scores as indicated in the table are 7.10±1.65, 6.95±1.70, 6.90±1.33, 7.75±0.97, 8.00±0.86 for sample RSA, RSB, RSC, RSD and RSE. There is sample RSD and RSE are significantly different from sample RSA, RSB and RSC, but there is no significant difference in the scoring for the colours of sample RSA, RSB and RSC.

General Acceptability

The scores as indicated in the table for the general acceptability of rice-based *sinasir* made from the five flour formulations are 7.20±1.74, 7.05±1.39, 6.90±0.91, 7.95±0.95, and 7.90±0.72 for the sample RSA, RSB, RSC, RSD, and RSE respectively. Sample RSD had the highest general acceptability scores followed RSE, RSA, RSB and RSC which has the lowest. Similarly, there was no significant difference ($p > 0.05$) between sample RSD and RSE. However, samples RSB and RSC were significantly different from sample RSD, RSE and RSA in terms of general acceptability

From Table 7, it can be observed that the significance value for aroma, taste, mouthfeel, colour and acceptability are

greater than 0.05, indicating that for all these sensory parameters, there is homogeneity for the samples RSA, RSB, RSC, RSD and RSE, and as well their variances are not significantly different for the rice-based *sinasir* enriched with plantain and sesame flour blends at various proportions. (This test is designed to test the null hypothesis that the variances of the samples are the same).
Since the significance value (p-value) is greater than 0.05, therefore there is homogeneity of variances. In other words, the variances between the two groups are equivalent or not significantly different.

Table 7: Sensory Evaluation of Samples

Samples	Aroma	Taste	Mouth feel	Colour	General Acceptability
RSA	6.80 ± 1.67^{a}	6.65 ± 1.39^{a}	6.60 ± 1.76^{a}	7.10 ± 1.65^{a}	7.20 ± 1.74^{b}
RSB	6.80 ± 1.28^{a}	6.65 ± 1.30^{a}	6.85 ± 1.50^{b}	6.95 ± 1.70^{a}	7.05 ± 1.39^{a}
RSC	6.90 ± 1.29^{b}	6.65 ± 0.99^{a}	6.75 ± 1.07^{a}	6.90 ± 1.33^{a}	6.90 ± 0.91^{a}
RSD	7.75 ± 0.85^{d}	7.45 ± 1.23^{b}	7.75 ± 1.02^{d}	7.75 ± 0.97^{b}	7.95 ± 0.95^{c}
RSE	7.60 ± 0.88^{c}	7.45 ± 0.69^{b}	7.50 ± 0.83^{c}	8.00 ± 0.86^{c}	7.90 ± 0.72^{c}

Values are Mean ± Standard Deviation of Replicate Analysis; Values with Different Superscripts Down the Column are Significant ($P<0.05$) Different.
Keys:
Sample RSA: Rice Flour 100%, Plantain Flour 0%, and Sesame Flour 0%
Sample RSB: Rice Flour 96%, Plantain Flour 5%, and Sesame Flour 1%
Sample RSC: Rice Flour 88%, Plantain Flour 10%, and Sesame Flour 2%
Sample RSD: Rice Flour 82%, Plantain Flour 15%, and Sesame Flour 3%
Sample RSE: Rice Flour 76%, Plantain Flour 20%, and Sesame Flour 4%.

CONCLUSION

Composite flour blends consisting of rice, unripe plantain, and sesame seed can be effectively utilized in the formulation of rice sinasir. This study demonstrated that the protein, ash (mineral), and vitamin contents of the sinasir increased progressively with higher inclusion levels of plantain and sesame flours. Regarding sensory evaluation, the formulation containing 82% rice, 15% plantain, and 3% sesame flour achieved the highest overall acceptability. Statistical analysis (\(p < 0.05\)) led to the rejection of the null hypothesis, confirming significant variations in aroma, taste, mouthfeel, colour, and overall acceptability among the evaluated samples (RSA to RSE).

Recommendations

The study recommends that other processing methods such as oven baking could be explored, experimented and the result should be compared and contrasted with the crude method used in the production to extract relative information. Further studies be carried out to ascertain the anti-nutritional contents of the *sinasir* samples. Also, microbiological analysis should be carried out on the *sinasir* products to ascertain the *sinasir* storage stability so to ascertain its shelf-life. Feeding trials, the product digestibility and the bioavailability of these nutrients in the rice-based *sinasir* should be determined.

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