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Physicochemical and Sensory Properties of Breakfast Meals Produced from Germinated Rice (*Oryza* sativa) and Pigeon Pea Flour Blends (*Cajanus cajan*)

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Abstract
This study evaluated the chemical and sensory properties of breakfast meals produced from germinated Rice (*Oryza sativa*) and Pigeon pea (*Cajanus cajan*). Two sample blends were formed with the blends at the ratio of 50%: 50% and 60%:40% germinated rice and germinated pigeon pea flour respectively. The control samples were 100% un-germinated rice flour and 100% germinated rice. The functional and pasting properties of the flours were determined. After this the breakfast meals were produced and their chemical and sensory properties were evaluated. The bulk density of the flours ranged from 0.75 g/ml to 0.88 g/ml, water absorption capacity from 1.83 to 2.73 g/g, and solubility index from 1.31 to 2.41 g/ml. The Peak viscosity of the flours ranged from 254.00 to 513.92 RVU, final viscosity; 302.33 to 533.08 RVU, peak time; 4.13 to 4.80 mins and pasting temperature; 77.7 to 80.6 ^{O}C. The crude protein, crude fibre and ash content of the breakfast meals ranged from 6.97 to 20.09%, 0.85 to 1.78% and 2.49 to 3.38 % respectively while anti-nutrients such as trypsin inhibitor, tannin and phytate ranged from 1.17 to 7.34 TIU/g, 0.41 to 2.14 mg/100g and 2.13 to 8.50 mg/100g respectively. The mineral composition of the samples ranged from 24.02 to 53.65 mg/100g for calcium, 1.15 to 1.95 mg/100g for iron and 10.33 to 29.62 mg/100g for Sodium. Breakfast meals produced with 100% germinated rice flour had the best organoleptic properties. Production of breakfast meals from blends of germinated rice and pigeon pea flours improved the nutrient compositions however, the organoleptic properties can further be improved for commercialization.

Keywords: Germination, breakfast meals, rice, pigeon pea, chemical, sensory properties

Introduction

As a result of changes in lifestyle and urbanization, the consumption of ready-to-eat breakfast meals is increasing. The major raw material in the production of breakfast meals is grains, mainly; corn, wheat, oats, rice and barley which are rich in carbohydrates thereby justifying why they are usually served with milk. Results from previous studies have shown that most cereals are limited in essential amino acids such as lysine, threonine and tryptophan and as such foods made solely from them will be deficient in these essential nutrients (D'Mello, 1993). Considering the high level of malnutrition in Nigeria which poses a serious problem, especially among children and the high cost of dairy products, there is the need to supplement the cereal grains used in making breakfast meals with under-exploited legumes which have the potential to provide better amino acid balance, dietary fibre, antioxidants and mineral content in an economic way (Shrivastava and Chakraborty, 2018).

Rice (*Oryza sativa*) is the most important staple food for about half of the human race (Imolehin and Wada, 2000). Saka and Lawal (2009) classified rice as the most important food depended upon by over 50 percent of the World's population for about 80 percent of their food need. In addition to its non-glutein characteristics, rice contains mainly carbohydrate which makes up almost 80% of its total dry weight, fiber most of which is contained in the bran and is lost during processing and a high concentration of vitamins (B vitamins) and minerals (Manganese, Magnesium, selenium, phosphorus etc.) on the bran and germ. They are also deficient in lysin just like other cereals (Katina *et al*, 2005). Cereal-based products are therefore supplemented with legumes as a good source of proteins including lysine and minerals (Awolu *et al*., 2017).

Pigeon pea (*Cajanus cajan* (L.) *Millspaugh*) is an important grain legume crop grown in tropical and subtropical regions of the world. It is called *agbugbu* or *fio-fio* in Igbo, and *waken Kurawa* or *otile* in some northern states. This perennial, drought-resistant leguminous shrub is an important source of proteins (20-22%), carbohydrates (65%), B-group vitamins, and minerals such as calcium (60.50 - 80.50mg/100g), phosphorous (334.00 – 550.00mg/100g) and magnesium (108 – 155mg/100g) (Kunyanga *et al*., 2013; Ayenan *et al.*, 2017) however, it is underexploited in food product development. Nigeria accounts for about 3.52% of the world's production of pigeon pea (Bhattacharjee *et al*., 2013; Fatokimi and Tanimonure, 2021). The seed is eaten as a green vegetable and dry pulse. Supplementation of cereals with protein rich legumes is considered one of the best solutions to alleviate protein-calorie malnutrition (Damaris, 2007) which is increasing due to population explosion and high food prices. The formulation of nutrient-rich food items from an economic source like pigeon pea offers an alternative strategy to combat the problem of malnutrition (Pelletier *et al*., 1995). Studies have shown that although legumes are known for their high protein content, their utility is limited because of their low protein digestibility (Echendu *et al*., 2009).

Germination is a simple process that is technologically effective in improving the nutritional properties of foods. It involves soaking the grains in water, allowing the grains to germinate and then halting the germination by drying them with hot air (Asouzu and Umerah, 2020). Germination develops the enzymes (α-amylase, β-amylase) required for modifying the grains' starches into various types of sugars (Liu and Xie, 2013; MacLeod and Evans, 2016) while proteolytic enzymes improve amino acid availability, particularly lysine, methionine and tryptophane that are lacking in legumes (Sokrab *et al.*, 2012). Many researchers have studied the effects of germination on the physical, physiological, biochemical, nutritional and functional properties of cereals and legumes and shown that germination can contribute to the reduction of antinutrients such as phytate thereby improving iron and zinc availability. It can also decrease the tannins and total phenolic contents (Olagunju and Ifesan, 2013). Vitamins (B and C) content increases significantly during germination (Coulibaly and Chen, 2011; Khatkar, 2013). Sokrab *et al.* (2012) found that germination improves calcium, copper, manganese, zinc, riboflavin, niacin and ascorbic acid content. Germination also enhances dietary fiber which plays an important role in gut health and also helps in lowering plasma cholesterol (Vasishtha and Srivastava, 2013). The objective of this study is to produce and evaluate breakfast meals produced from a blend of germinated Rice and Pigeon Pea flour.

Materials and Methods

Sources of Raw Materials

The major raw materials for this study were Rice paddy (*Oryza sativa*) and Pigeon pea grains (*Cajanus cajan* (L.) Millspaugh). The rice paddy was purchased from Eke local Market in Ishiagu, Ivo Local Government Area of Ebonyi state while the pigeon pea grains were bought from New Haven market in Enugu state. Other minor ingredients such as salt, sweeteners (sugar), milk, butter and flavouring were purchased from Ubani local market, Umuahia in Abia State. The laboratory analyses were conducted at the laboratory of Food Science and Technology Department, Umudike.

Sample Preparation

Production of germinated and un-germinated Rice Flour (GRF & URF)

The rice paddy was divided into two portions; one portion was sorted, cleaned, dehulled, winnowed, milled and sieved (210µm mesh size) to obtain un-germinated rice flour (URF). The other portion was germinated according to the method described by Kunze (2005). The rice grains were sorted, cleaned and steeped in water 25 ^oC for 36 hours with alternative 12 hours wet-steep and 45 minutes air-rest period. At the end of the steeping process, the rice grains were couched on jute bags previously sterilized with dry heat. Samples were germinated within a temperature range of 30 ^oC – 33 ^oC, for 3 days. Drying was performed in a hot air-oven (Surgified Medical England model SM9123A) at a temperature of 60 ^oC for 3 hours with continuous turning to achieve uniform drying. Dried samples were manually de-rooted by rubbing in-between the palms followed by dehulling and winnowing to remove the chaff. The dehulled rice was then milled with an attrition mill and sieved (210µm mesh size) to obtain germinated rice flour (GRF) which was stored in a sealed plastic container until required for further processing.

Production of Germinated Pigeon Pea Flour (GPF)

The method described by Asouzu and Umerah (2020) was used in processing of germinated pigeon pea flour. The Pigeon pea seeds (2kg) were sorted to remove dirt and other extraneous materials. The seeds were then steeped in water for 24 hours while changing the steep water 6 hourly. The resultant steeped grains were thinly spread on jute bags and allowed to germinate at a temperature range of 30 – 33 ^0C for 4 days. The germinated seeds were then dried in hot air oven (Surgified model SM9123A) to a temperature of 54 ^0C for 3 hours, cooled, de-rooted manually by rubbing in between the palms, dehulled using abrasion and milled into flour with an attrition mill and sieved (210µm mesh size).

Blending of germinated rice and pigeon pea flours

The rice and pigeon pea flours were blended in the following ratios: (Table 1).

Functional Properties of the Flour Blends

The bulk density, water and oil absorption capacity, gelatinization temperature and swelling index of the flour blends were determined using the methods described by Onwuka, (2018).

Pasting Properties of Flour Blends

The method described by Ojo *et al*. (2017) was adopted to determine the pasting properties of the composite flours using a Rapid Visco Analyzer (RVA 4500). A flour sample (2.5 g) was weighed into a previously dried canister and 25 ml of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed and the canister was fitted into the Rapid Visco Analyzer (RVA 4500) as recommended. Each suspension was kept at 50 °C for 1 min. and then heated up to 95 °C with a holding time of 2 min.

followed by cooling to 50 °C for 2 min. holding time. The rate of heating and cooling was at a constant rate of 11.85 °C per min. Peak viscosity (PV), trough viscosity (TV), breakdown viscosity (BDV), final viscosity (FV), and set back viscosity (SBV), were read from the pasting profile with the aid of thermocline for windows software connected to a computer.

Production of Breakfast Cereal

The recipe used for the production of breakfast cereal is presented in Table 2 and the production of breakfast cereal was in accordance with the method described by Dada *et al*., (2017). The ingredients were mixed, and the batter obtained was thinly poured on a well-greased stainless-steel tray and placed in the gas oven at a temperature of 100°C for 20mins. Until it was semi-dry after which it was cut into small sizes and returned to the oven at 280°C with continuous stirring for 15mins until completely toasted.

Proximate Analyses on breakfast meals

The moisture, ash, fat, crude fibre and crude protein content of the breakfast cereals were determined according to the standard methods of AOAC (2005). Carbohydrate content of the breakfast cereal samples was determined by difference.

% carbohydrate =100 − % (protein + fat + fibre + ash + moisture content)

Mineral Composition of Breakfast Cereals

The Calcium, Sodium and Iron content of the breakfast cereals were determined according to the method of AOAC (2005). The samples were ashed and 15mL of 6N HCl was added and distilled water was used to make it up to 100mL mark of the volumetric flask. Atomic absorption spectroscopy (Perkin-Elmer, USA) was used to analyze the calcium and iron content while the sodium content was analyzed using a flame emission spectrophotometer (Shimadzu Corporation and Kyoto, Japan).

Analysis of Anti-nutritional Factors

Determination of phytic acid content

The sample (2 g) was weighed into 250 mL conical flask; 100 mL of 2 % concentrated HCl was thereafter added, allowed to soak for 3 h and filtered. The filtrate (50 mL) was pipetted into 250 mL beaker, with 107 mL ammonium thiocyanate solution added as an indicator and titrated with standard iron III chloride $FeCl_3$ solution (containing 0.00195 g iron/mL) until a brownish yellow colour appeared and persisted for five minutes (Russell, 1980). The phytic acid content was calculated as follows:

$$\text{Phytic acid} = \frac{0.00195 \times \text{VF eCl 3} \times \text{DF}}{\text{Weight of sample}} \dots (1)$$

VF eCl_3 = volume of F eCl_3 consumed

DF = Total volume of extraction solvent added/volume of aliquot taken for the titration.

Determination of tannin content

The sample (0.2 g) was placed in a test tube, 10 mL of 1 % HCl/methanol was added, the test tube was capped, continuously shaken for 20 min and then centrifuged at 2500 rpm for 5 min. Exactly 1 mL of the supernatant was pipetted into fresh tubes, the absorbance was set at zero and 1 mL blank solution was mixed with 5 mL 4 % HCl/methanol and 5 mL vanillin reagent in a test tube. The sample and blank test tubes were incubated for 20 min at 30 °C. Absorbance was read at 500 nm and the concentration of condensed tannins was determined from a standard curve (Trease & Evans, 1978). Tannin concentration was expressed in % as follows:

$$\text{Tannic content} = \frac{\text{C} \times \text{volume of extract}}{\text{Weight of sample (mg)}} \dots (2)$$

Where: C= Concentration corresponding to the optical density

Determination of trypsin inhibitor

Tris-buffer (0.05 M, pH 8.2) containing 0.02 M $CaCl_2$: 6.05 g tris- (hydroxymethyl) aminomethane and 2.94 g $CaCl_2 \cdot 2H_2O$ were dissolved in 500 mL of distilled water, the pH was adjusted to 8.2 and the volume made up to 1 L with distilled water. About 2.0 mL of trypsin solution was added to 1.0 g of the extracted sample in a test tube and then placed in a water bath at 37 °C. Exactly 5 mL hydrated Benzoyl-DL arginene-p-nutoanilide (BAPA) solution was dissolved in dimethyl sulfoxide previously warmed to 37 °C. The reaction was terminated 10 min later by adding 1 mL of 30 % acetic acid. After thorough mixing, the contents of each tube were filtered through Whatman No.1 paper and the absorbance was measured against the blank (Kakade, 1974).

Sensory Evaluation of the Breakfast Meals

The sensory evaluation of the breakfast cereal was carried out according to the method described by Iwe (2014). A total of 25 semi-trained panelists performed the sensory test to assess the appearance, taste, aroma, mouth-feel and overall acceptability of the breakfast meal on a 9-point Hedonic scale (1 = dislike extremely and 9 = like extremely). The breakfast cereals were reconstituted in water, separately coded and presented to panelists in individual booths to avoid bias. A questionnaire describing the quality attributes of the samples was given to each panelist. The panelists were provided with portable water to rinse their mouth between evaluations.

Statistical Analysis

The results of all determinations were expressed as means of duplicate values. Data were subjected to One-way Analysis of Variance (ANOVA) and significant differences were detected using Duncan multiple range test at 95% confidence level ($p<0.05$). An IBM SPSS Statistical package (version 22.0) was used for all statistical analyses.

Results and Discussion

Functional Properties of Flour Blends

Table 3 shows the functional properties of the flour samples. The Bulk density (BD) obtained in this study ranged from 0.75 (100% URF) to 0.88 g/ml (50% GRF:50%GPF) which is higher than 0.35g/mL reported for maize-bambara groundnut flour blend by Mbata *et al*, (2009). The bulk density of the germinated rice flour and the blends were significantly ($p<0.05$) higher than that of un-germinated rice flour. Suggesting that the germinated rice flour and the blends are denser and hence would occupy less space per unit weight which suggests a better packaging advantage since more flour can be kept in a given space (Ezeocha and Onwuka, 2010). The presence of fibre contributes to the bulkiness of a flour sample (Akinjayeju & Ajayi, 2011). This could be responsible for the increase in bulk density of the breakfast meals substituted with GPF as it has been reported that pigeon pea is rich in fibre (2.28 – 3.06%) (Anjulo *et al*., 2021). Suresh *et al.* ((2015) reported that BD is also dependent on the particle size, starch, and initial moisture content of flour.

The water absorption capacity (WAC) of the flours and blends ranged from 1.83 (100% GRF) to 2.73 g/g (100% URF) which were lower than the values of 2.20 to 4.81g/g reported by Tenagashaw *et al.* (2015) for complementary foods from teff fortified with soybean and Orange-fleshed sweet potatoes. The WAC of GRF was significantly ($p<0.05$) lower than that of URF, this may be due to hydrolysis of starch polymer into simpler carbohydrates with lower WAC during germination (Adebowale *et al*., 2010). Flours with low water absorption produce thin gruels which are desirable in the formulation of infant complementary foods (Onwuluzo & Nwabugwu, 2009). Blending the germinated rice flour with germinated pigeon pea flour significantly ($p<0.05$) increased the WAC of the flours. This may be due to an increase in polar groups as a result of low molecular weight proteins produced during hydrolysis that takes place during germination which influence the hydrophilic capacity of the flour making it bind more water (Kaur & Singh, 2005; Odoemelam, 2003). It could also be due to the fact that pigeon pea contains highly insoluble fibre which strongly absorbs water (Pla *et al*, 2006). Water absorption capacity (WAC) is the capacity of the flour to absorb water and swell for enhanced consistency in food (Blessing, 2014). It is desirable in the production of breakfast meals. It depends on the availability of the hydrophilic groups which bind the water molecules (Tenagashaw *et al.*, 2015). From the above result, it can be deduced that germination decreased the water absorption capacity of cereals and the addition of germinated pigeon peas increased the water absorption capacity of the flour blends.

The swelling index of the samples ranged from 1.31 (100%GRF) to 2.41 g/ml (60% GRF: 40% GPF). The swelling index of 100% GRF was significantly lower than that of 100% URF, however, blending GRF with GPF significantly ($p<0.05$) increased the swelling index. Swelling capacity is related to protein and starch contents in foods (Woolfe, 1992) as well as the amylose – amylopectin ratio of the starch (Adebowale *et al*, 2005). The differences in the swelling index may be due to differences in the molecular organization of the starch granules (Adebowale *et al*., 2005). The swelling index is a function of the volume increase of the product when interacting with water. It is an indication of the extent of associative forces within flour granules and depends on the particle size, variety and type of processing or unit operation (Obiegbuna *et al.,* 2019). The swelling index (SI) is considered a quality measure in most food products.

The gelatinization temperature (GT) of the flour blends ranged from 77.60 (100% URF) to 80.65 ^{o}C (50%GRF:50%GPF). Germination significantly ($p<0.05$) increased the gelatinization temperature of the rice flour and the addition of pigeon pea flour further increased the gelatinization temperature of the flour blends. This implies that the preparation of breakfast meals made from the blends will consume more energy than that made from 100% URF. GT is the temperature at which food materials form gel or become gelatinous (Ezeocha & Onwuka, 2010).

Pasting Properties of the Rice-Pigeon Pea Flour blends

The result of the pasting properties of the flours and blends are shown in Table 4. The peak viscosities (PV) of the flours were significantly ($p<0.05$) different and ranged from 254.00 (50%GRF:50%GPF) to 513.92 RVU (100% URF). The peak viscosity of the rice flour was reduced in the germinated sample and in samples substituted with GPF. This could be attributed to the breakdown of starch into lower molecular weight sugars during germination as well as the dilution of the carbohydrate content of the flour blends with GPF with lower carbohydrate content (54.36 – 60.1%) (Anjulo *et al*., 2021). The low PV of 50%GRF:50%GPF indicates that the flour will not form a very thick paste. PV reflects the capacity of the starch to absorb water and swell. It is suggestive of the strength of pastes which are formed from gelatinization during processing (Maziya-Dixon *et al*., 2007). The Trough Viscosity (TV) of the flour samples ranged from 158.00 (50%GRF:50%GPF) to 358 RVU (100% URF). TV reduced with an increase in GPF, this indicates that 100% URF can withstand high heat treatments during processing than the flour samples substituted with GPF. Trough viscosity is the minimum viscosity in the constant temperature phase of the RVA profile measuring the ability of paste to withstand breakdown during cooling. High trough viscosity may represent low cooking losses and better eating quality (Bhattacharya *et al*., 1999). The breakdown viscosity which reflects the stability of the peak viscosity ranged from 76.00 (100% URF) to 174 RVU (50%GRF:50%GPF). The BV of the flour samples is significantly ($p<0.05$) different. Sample 50%GRF:50%GPF with higher BV implies that it is less resistant to heat and shearing during cooking than the other samples (Adebowale *et al*., 2005) which can be attributed to the lower starch content of legumes such as pigeon pea (Ayenor, 1985). The final viscosity of the flour samples ranged from 302.33 (50% GRF:50% GPF) to 533.08 RVU (100% URF). The final viscosity of the flour samples was significantly ($p<0.05$) different from each other. The results show that the inclusion of GPF significantly ($p<0.05$) reduced the final viscosity of the flours. Setback viscosity is an indication of the retrogradation tendency of a paste (Sandhu *et al*., 2007). The highest setback value was observed in 50%GRF:50%GPF (164.33RVU) suggesting its lower propensity to exhibit retrogradation which is a beneficial attribute. The results indicated that flours with GPF substitution have lower retrogradation potential than the 100% URF and GRF. This can be attributed to the high fibre content (2.28 – 3.06%) of pigeon pea (Anjulo *et al*., 2021) as fibre has been reported to have good water absorption property that gives good stabilizing effects on foods (Ahmed *et al*., 2018). The pasting temperature of the flour samples ranged from 77.7 to 80.6 °C. This is the minimum temperature needed for gelatinization which is important in managing energy costs (Kaur & Singh, 2005). The pasting temperature of all the samples is lower than the boiling point of water (100°C), which shows that they can form a paste in hot water below the boiling point. Peak time which is the total time taken by each sample to get to its peak viscosity; ranged from 4.13 (100% URF) to 4.80 (50%GRF:50%GPF).

Proximate Composition of Rice-Pigeon-BasedBreakfast Meal

The results for the proximate analysis are shown in Table 5. The moisture content of the samples ranged from 4.74 (100% GRF and 50GRF: 50GPF) to 7.84% (100% URF) which was within the acceptable range (≤ 10%) to ensure shelf stability (Blessing, 2014). There were significant ($p<0.05$) differences in the moisture content of the samples. The low moisture content of the breakfast meals makes them easy to store at room temperature and less prone to fungal and microorganism infections. The crude protein content of the breakfast meals ranged from 6.97 (100% URF) to 20.09% (50% GRF:50%GPF). The crude protein of the breakfast meals Showed a progressive increase significantly ($p<0.05$) with the addition of GPF. A similar observation was made by Chinma *et al*. (2022) on biscuits prepared from germinated finger millet and Bambara groundnut flour blends. Legumes such as pigeon pea, have higher protein content (19.28 – 25.79%) than cereals such as rice, maize etc. (Anjulo *et al*., 2021). The crude fiber content of the breakfast meals ranged from 0.85 (100% GRF) to 1.78% (50% GRF: 50% GPF). Crude fiber contents of the blends increased slightly with the substitution of GRF with GPF. Crude fiber which is comprised of indigestible carbohydrates such as cellulose, hemicellulose, pectin, and lignin; reduces the rate of release of glucose into the bloodstream and also reduces inter-colonic pressure thereby reducing the risk of colon cancer (Awuchi, 2019). The fat content of the breakfast meals ranged from 1.06 (100% GRF) to 1.52% (100% URF). The use of fat as an energy source and increased activities of the lypolytic enzymes during germination which hydrolyzed fats to fatty acids and glycerol may explain the low-fat content of the samples from 100% GRF. The fat content observed in this study is similar to the values of 1.30 to 7.34% reported by Nwosu *et al.* (2013) for malted pigeon pea flour. The relatively high-fat content of samples from 100% URF implies that it can give more energy and contain more fat-soluble vitamins than the other samples. The generally low-fat content of the breakfast meals implies that they are not vulnerable to oxidative rancidity (Tenagashaw *et al.,* 2015). The ash content ranged from 2.49% (100% URF) to 3.38% (50% GRF:50% GPF). The ash content of samples from 100% GRF was significantly ($p<0.05$) higher than that from 100% URF. It was observed that the substitution of GRF with GPF caused a corresponding increase in the ash content of the breakfast meals. This could be due to the fact that pigeon pea is a rich source of minerals such as calcium, potassium, phosphorus and magnesium (Samaila *et al.,* 2020). An increase in ash content as a result of GPF addition to GRF could imply an increase in the number of minerals in the breakfast meal. Minerals are essential micronutrients which serve a variety of essential functions in metabolism and are among the parts of biomolecules such as hemoglobin, deoxyribonucleic acid (DNA), and adenosine triphosphate (ATP) (Awuchi, 2019). The carbohydrate content ranged from 68.15% (50% GRF:50% GPF) to 81.22% (100% GRF). There was a significant ($p<0.05$) decrease in carbohydrates with the inclusion of GPF in the breakfast meals. This could be due to the fact that pigeon pea flour has less carbohydrate content (54.36 – 60.1%) than GRF (81.22%) (Anjulo *et al*., 2021). Carbohydrates are good sources of energy (Awuchi, 2019). A high concentration of carbohydrates is desirable in breakfast meals.

Mineral Composition of Germinated Rice- Pigeon Pea-based Breakfast meal

The mineral contents of the breakfast meals are shown in Table 6. The calcium content of the breakfast meals ranged from 24.02 (100% URF) to 53.65 mg/100g (50% GRF:50%GPF). The calcium content increased with the addition of GPF. The values obtained suggested that the consumption of every 100 g of the breakfast meal would result to a calcium intake that is below the FAO/WHO recommended daily intake for calcium of different target consumers such as Infants and children of 0 to 9 years (300 to 700 mg/day), Adolescents of 10 to 18 years (1300 mg/day), adults of 19+ years (1000 to 1300 mg/day), pregnant women (1200 mg/day) and lactating women (1000 mg/day) (FAO/WHO, 1998). Calcium has been found to promote bone formation, contraction of the muscles and assists in blood clotting. Although the breakfast meals with the inclusion of GPF had improved calcium contents, it is still below the FAO/WHO recommended daily intake and might possibly not provide the needed calcium for the body's needs. Hence they need to still take breakfast meals with milk which is a rich source of calcium. The sodium content of the breakfast cereal ranged from 10.33 (100% URF) to 29.62 mg/100g (50% GRF:50%GPF). The breakfast meals from the GRF and GPF blends had higher sodium content than the control sample (100% URF), thus, the production of breakfast meals from rice and pigeon pea flours resulted in products with higher sodium content. Low sodium content is beneficial to health, especially in the aspect of blood pressure regulation (Onwuka, 2018). The iron content of the breakfast meals ranged from 1.15 (100% URF) to 1.95 mg/100g (50% GRF:50%GPF). The addition of GPF resulted in a significant ($p<0.05$) increase in the iron content of the breakfast meals. However, the iron content of the breakfast cereals was below the recommended daily intake for infants and children (5.90 to 6.20 mg/day), adolescents (9.30 to 20.70 mg/day for females and 9.70 to 12.5 mg/day for males) and adults (19.60 mg/day for females and 9.10 mg/day for males) respectively (FAO/WHO, 1998). Iron deficiency leads to anaemia (World Health Organization, 2001).

Anti-Nutritional Composition of the Breakfast Meals

The results of the anti-nutrient composition of the rice–pigeon pea-based breakfast meals are shown in Table 7. The trypsin inhibitor of the breakfast meals ranged from 1.17 (100% GRF) to 7.34 mg/100g (50% GRF:50% GPF). The result from this work shows that the inclusion of germinated pigeon increased the trypsin inhibitor content of the breakfast meals. The low trypsin inhibition content of breakfast meals from 100% GRF could be a result of germination which had a significantly decreasing effect on the trypsin inhibitor content of the breakfast meals. Trypsin inhibitors cleave with proteins thereby preventing the binding of protein and trypsin thus affecting the digestion of protein (Aviles-Gaxiola *et al.,* 2018). The values obtained in this study are quite low and might not influence protein digestion negatively. The tannin content ranged from 0.41 (100% GRF) to 2.14 mg/100g (50%GRF: 50%GPF). Addition of GPF resulted in increased tannin content in the breakfast meals. However, the tannin in the breakfast meal was generally below the reported lethal dose of 90 mg/100g (Ifie and Emeruwa, 2011). Therefore, the tannin level in breakfast meals might not influence digestion negatively since high tannin concentration interferes with protein digestibility (Ferrell and Thorington, 2006). The Phytate content (2.13 to 8.50 mg/100g) of the breakfast meals was lower than 25 mg/100g, which is the amount considered lethal to health (Ifie and Emeruwa, 2011). The Germinated samples (100% GRF, 50% GRF:50% GPF and 60%GRF:40%GPF) had lower phytate contents compared to the control sample (100% URF) which recorded the highest phytate content. The reduction in phytate is possibly due to the effect of germination, as soaking and germination processes reduce antinutrients like phytic acid (Thakur *et al*., 2021). Phytate is often considered an antinutrient because it binds minerals (Zn^{2+}, $Fe^{2+}/^{3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+}) in the digestive tract, making them unavailable (Pirgozliev *et al.,* 2019).

Sensory Properties of Germinated rice-pigeon pea-based breakfast Meals

The sensory scores of the rice-pigeon pea-based breakfast meals are presented in Table 8. Appearance is a significant parameter in assessing the quality of food materials; it is also a pointer to raw materials and the adequacy of formulation of the product (Ogundele *et al.,* 2015). The appearance score of the breakfast meals ranged from 5.55 (50% GRF: 50% GPF) to 7.75 (100% GRF). The slightly liked appearance of 50% GRF: 50% GPF breakfast meal could be attributed to the darker colour of the sample which could be a result of Maillard reaction between the amino acids in GPF and reducing sugars in GRF during drying.Taste is the sensation of flavor perceived in the mouth and throat on contact with a substance and it is one of the most important attributes watched out for in a food product. Taste could be affected by the types and quality of ingredients and could also depend on the formulation of the food material (Small and Prescott, 2005). Means of taste scores of the breakfast meals ranged between 5.10 (50% GRF: 50% GPF) and 8.00 (100% GRF). The low taste score of the blended samples could be attributed to the beany after taste which was impacted on the samples by the GPF. Hence, the taste of the breakfast meal with 50% inclusion of GPF was neither liked nor disliked (5.10). Aroma is a distinctive, typical pleasant smell perceived by the olfactory sense (Small and Prescott, 2005). The breakfast meal with 100% GRF scored the highest (7.75) for aroma and did not differ significantly ($p> 0.05$) from 100% URF (control), while the sample with 50% GRF:50% GPF scored the least (5.75). This implies that the inclusion of GPF to the breakfast meal up to 50% made the aroma to be liked slightly (5.75) by the panelists. The texture score range of the breakfast meals was 5.30 (50% GRF: 50% GPF) to 7.65 (100% GRF). From the result, the inclusion of germinated pigeon pea flour significantly ($p<0.05$) reduced the texture of the breakfast cereals. This could be due to the reduction in starch content which reduced the ability of the samples to bind to each other when reconstituted. From the panelists score, the texture of samples with 50% GRF: 50% GPF was neither liked nor disliked (5.50). The breakfast cereal with 50% GRF: 50% GPF had the lowest overall acceptability score (5.75) which was significantly ($p < 0.05$) different from that of samples from 60%GRF: 40%GPF (6.16) and 100% URF (7.90) while samples with 100% germinated rice flour had the highest general acceptability score (8.15). Overall acceptability refers to the general acceptance of the product with reference to all the discriminating sensory attributes of the sample (Ogundele *et al.,* 2015). Generally, the results showed that the substitution of GRF with up to 50% GPF in the production of breakfast meals reduced the acceptability of the breakfast meal but however, the product was still liked slightly.

Conclusion

The addition of germinated pigeon pea to germinated rice significantly improved the nutrient composition of the breakfast meals in all the parameters measured. The functional and pasting properties of the germinated rice flour were greatly improved with the addition of germinated pigeon pea flour. All the breakfast meals had appreciable acceptability except the 50:50 germinated rice and pigeon pea-based breakfast meal which had the least acceptability in terms of appearance, taste, mouth feel and aroma. The inclusion of germinated pigeon pea even though improved the nutrient composition of the breakfast meals adversely affected its sensory acceptability. Both nutrient and sensory acceptability are key quality parameters of a product. Hence there is need for further study on ways to improve the sensory properties of this nutritious breakfast meal.

References

Adebowale, Y.A., Adeyemi, A. & Oshodi, A.A. (2005). Variability in the physicochemical, nutritional and antinutritional attributes of six Mucuna species. *Food Chemistry*, 89(1), 37-48. Doi:10.1016/j.foodchem.2004.01.084.

Ahmed, J., Almusallam, A.S., Al-Salman, F., AbdulRahman, M.H., Al-Salem, E. (2013). Rheological properties of water insoluble date fiber incorporated wheat flour dough. *LWT-Food Science and Technology*, 51(2): 409-416.

Akinjayeju, O.. & Ajayi, O.F. (2011). Effects of dehulling on functional and sensory properties of flours from black beans. Doi:10.4236/fns.2011.24049.

Anjuola, M.T., Doda, M.B. and Kanido, C.K. (2021). Determination of Selected Metals and Nutritional Compositions of Pigeon pea (Cajanus cajan) cultivated in Wolaita Zone, Ethiopia. *Journal of Agricultural Chemistry and Environment*, 10, 37-56. Doi:10.4236/jacen.2021.101003.

AOAC. (2005). Official methods of analysis. 15th edn. (Gaithersburg, S. edn). AOAC Press, Washington DC., USA. pp. 78- 90.

Asouzu, A.I. & Umerah, N. (2020). Effects of malting on Nutritional characteristics of Pigeon pea (*Cajanus cajan*). *Asian Journal of Biochemistry Genetics and Molecular Biology*. Doi:10.9734/ajbgmb/2020/v3i230083.

Aviles-Gaxiola, S., Chuck-Hernandez, C., and Serna Saldivar, S.O (2018). Inactivation methods of trypsin inhibitor in legumes: a review. *Journal of Food Science* 83 (1): 17–29. doi:10.1111/1750-3841.13985.

Awolu,O.O., Oyebanji, O.V. and Sodipo, M.A.(2017). Optimization of proximate composition and functional properties of composite flours consisting wheat, cocoyam(Colocasia esculenta) and bambara groundnut (*Vigna subterranean*). *International Food Research Journal*, 24(1): 268-274.

Awuchi, C. G. (2019). Proximate Composition and Functional Properties of Different Grain Flour Composites for Industrial Applications. *International Journal of Food Sciences*, 2(1):43-64, nov. 2019. ISSN 2520-4637. *https://www.iprjb.org/journals/index.php/ IJF/ article/view/1010.*

Ayenan, M. A.T., Danquah, A.., Ahoton, L.E. and Ofori, K.., (2017). Utilization and farmers' knowledge on pigeon pea diversity in Benin. *West Africa. Journal. Ethnobiol. Ethnomed*. 13:37.

Ayenor, G.S. (1985). Effects of the retting of cassava on product yield and cyanide detoxification. *International Journal of Food Science & Technology*, 20(1), 89-96. Doi:10.1111/j.1365-2621.1985.tb01907.

Bhattacharya, M., Zee, S.Y., & Corke, H. (1999). Physicochemical properties related to rice noodles. *Cereal Chemistry*, 76(6), 861-867. Doi:10.1094/CCHEM.1999.76.6.861.

Blessing, I. O. (2014). Chemical, functional & pasting properties of wheat (triticumspp) –walnut (juglansregia) flour. *Food and Nutrition Sciences*, 5: 1591-1604. Available online at http://dx.doi.org/10 .4236/fns. 2014.516172.

Coulibaly, A and Chen J. (2011). Evaluation of energetic compounds, antioxidant capacity, some vitamins and minerals, phytase and amylase activity during germination of foxtail millet. *American Journal of Food Technology,* 6: 40–51.

Chinma, C.E. Ibrahim, P.A., Olajide Adedeji, O.E., Ezeocha, V.C., Ohuoba, E.U., Kolo, S.I. Abdulrahman, R., Anumba, N.L.O., Adebo, J.A., Adebo, O.A. (2022). Physicochemical properties, in vitro digestibility, antioxidant activity and consumer acceptability of biscuits prepared from germinated finger millet and Bambara groundnut flour blends. *Heliyon*, 8. https://doi.org/10.1016/j.heliyon.2022.e10849.

Dada, T. A., Barber, L. I., Ngoma, L. and Mwanza, M. (2017). Formulation, sensory evaluation, proximate composition and storage stability of cassava strips produced from composite flour of cassava and cowpea. *Food Science and Technology,* 6:395-399.

Damaris, A.O. (2007). The potential of Pigeon pea (*Cajanus cajan* (L.) Millsp.) in Africa. Natural Resources Forum, 31, 297-305.

D'Mello, J.P.F. (1993). Amino acid supplementation of cereal-based diets for non-ruminants. *Animal Feed Science and Technology*, 4(1): 1-18.

Echendu, C.A., Obizoba, I.C. and Anyika, J.U. (2009). Effects of germination on chemical composition of groundnut (*Kerstingiella geocarpa harm*) seeds. *Pakistan Journal of Nutrition*, 8(12): 1849-1854.

Ezeocha, V.C. and Onwuka G.I. (2010). Effect of processing methods on the physicochemical and nutritional quality of maize and soybean based complementary blend. *Nigerian Food Journal,* 28 (2): 210 – 216.

FAO/WHO. (1991). Protein quality evaluation; report of the joint FAO/WHO expert consultation; Rome, Italy, 1991.

FAO/WHO (1998) Preparation and use of Food-Based Dietary Guidelines, Report of a Joint FAO/WHO Consultation WHO Technical Report series 880, Geneva.

Fatokimi, E. O. and Tanimonure, V. A. (2021): Analysis of the current situation and future outlooks for pigeon pea (*Cajanus Cajan*) production in Oyo State, Nigeria: A Markov Chain model approach. *Journal of Agriculture and Food Research,* (6) 16-21, December 2021,100218.

Ferrell, K. E. and Thorington, R. W. (2006). *Squirrels: the animal answer guide*. Baltimore: John Hopkins University Press. 91. ISBN 978-0-8018-8402-3.

Ifie, I. and Emeruwa, C. (2011). Nutritional and anti-nutritional characteristics of the larva of Oryctes monoceros. *Agri. Bio. J. North America*, (1992):

42–46. http://doi.org/10.5251/abjna.2011.2.1.42.46
Imolehin, E.D. and wada, A.C. (2000). Meeting the rice production and consumption demands of Nigeria with improved technologies. International Rice Commission Newsletters, 49, 23-41.
Iwe, M. O. (2014). *Current trends in sensory evaluation of foods*. Revised Edition. Rojoint Communication Services Ltd. Uwani Enugu, Nigeria. Pp. 144-145.
Kakade, M. L. (1974). Biochemical basis for the differences in plant protein utilization. *Journal of Agricultural and Food Chemistry*, 22 (4), 550–555. doi:10. 1021 / jf60194a014.
Katina, K., Arendt, E., Liukkonen, K.,H., Autio, K., Flander, L., and Poutanen, K. (2005). Potential of Soughdough for healthier cereal products. *Trends in Food Science and Technology*, 16(1-3):104-112.
Kaur, M., & Singh, N. (2005). Studies on functional, thermal and pasting properties of flours from different chickpea (*Cicer arietinum* L.) cultivars. *Food Chemistry*, 91(3), 403-411. Doi:10.1016/j.foodchem.2004.06.015.
Khatkar, B.S. (2013). A manual on quality testing of wheat flour and bakery ingredients. Post graduate diploma in bakery science and technology (PGDBST – 03). Guru jambheshwar university of science and technology, Hisar – 125 001.
Kunyanga, C. Imungi, J. and Vellingiri, V. (2013) Nutritional evaluation of indigenous foods with potential food-based solution to alleviate hunger and malnutrition in Kenya. *Journal Application Bioscience,* 67**:** 5277-5288.
Kunze, W. (2005). *Technology of Brewing and Malting*. VLB, Berlin. 110.
Liu, Y.W. and Xie, W.H. (2013). Effect of germination conditions on phytic acid and polyphenols of faba bean sprouts (Vicia Faba L.) *Legume Research*, 36 (6): 489 – 495.
MacLeod, L. and Evans E. (2016). *Malting: Reference Module in Food Science*. Elsevier, Amsterdam, Netherland, pp. 1-11.
Maziya-Dixon, B., Dixon, A.G.O. A. and Adebowale, A.A. (2007). Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. *International Journal of Food Science and Technology*, 42:969-976.
Mbata, T.I., Ikenebomeh, M.J., & Ezeibe, S. (2009). Evaluation of mineral content and functional properties of fermented maize (Generic and specific) flour blended with Bambara groundnut (Vigna subterranean L.). *African Journal of Food Science*, 3(4). 107-112.
Nwosu, J.N. Ojukwu, M., Ogueke, C.C., Ahaotu, I. and Owuamanam, C.I. (2013). The Anti-nutritional properties and ease of Dehulling on the proximate composition of Pigeon Pea (*Cajanu scajan*) as affected by malting. *International Journal Life Science,* 2: 60-67.
Obiegbuna, J. E., Nwankwo, A.J., Ozue, J. O. and Okolo, C. A. (2019). Evaluation of Yield & Physicochemical Properties of Single Cereal Grain Akamu and Pre- and Post- Processed Multigrain Cereal Akamu Powders. *International Journal of Food and Nutrition Research*, 3: 29.
Odoemelam, S.A. (2003). Chemical composition and functional properties of conophor nut (Tetracarpidium conophorum) flour. *International Journal of Food Science and Technology*, 38(6), 729-734. Doi:10.1046/j.1365-2621.2003.00725.x.
Ogundele, G.F., Ojubanire, B.A. and Bamidele O.P. (2015). Proximate composition and organoleptic evaluation of cowpea (*Vigna uguculata*) and soyabean (Glycine max) blends for the production of moi-moi and Ekuru (steamed cowpea paste). *Journal of Experimental Biology and Agricultural Sciences,* 3(2):207-212. Doi:10.18006/2015.3(2).207-212.
Ojo, M.O., Ariahu C.C. and Chinma E.C. (2017). Proximate, functional and pasting properties of cassava starch and mushroom (*Pleurotus pulmonarius*) flour blends. *American Journal of Food Science & Technology*, 5 (1), 11 – 18. DOI: 10.12691/ajfst-5-1-3.
Olagunju, A. I. and Ifesan, B. O. T. (2013). Nutritional composition and acceptability of cookies made from wheat flour and germinated sesame (*Sesamum indicum*) flour blends. *British Journal of Applied Science & Technology,* 3: 702-713.
Onwuka, G. I. (2018). *Food Analysis and Instrumentation. Theory and practices*. Naphtali Prints Lagos, Nigeria.
Onwuluzo, J.C., & Nwabugwu, C.C. (2009). Fermentation of millet (Pennisetum americanum) and pigeon pea (Cajanus cajan) seeds for flour production: Effects on composition and selected functional properties. *Pakistan Journal of Nutrition*, 8(6), 737-744.
Pelletier, D.L., Frongillo, E.A., Schroeder, D.G. and Habicht, J.P. (1995). The effect of malnutrition on child mortality in Developing countries. Bulletin of the world Health Organization, 3, 443-448.
Pirgozliev, V., Brearley, C.A., Rose, S.P. and Mansbridge, S.C. (2019). Manipulation of plasma myoinositol in broiler chickens: effect on growth performance, dietary energy, nutrient availability, and hepatic function. *Poultry Science*, 98(1): 260-268.
Pla, M.D.E., Delbon, M., Rojas, A.M. & Gerschenson, L.N. (2006). Effect of immersion and turgor pressure change on mechanical properties of pumpkin (*Cucumis moschata, Duch*.). *Journal of the Science of Food and Agriculture*, 86(15), 2628-2637. Doi:10.1002/jfsa.2663.
Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, 39 (6), 1161–1178. doi:10 . 1037 / h0077714.
Saka, J.O. and Lawal, B.O. (2009). Determinants of adoption and productivity of improved rice varieties in southwestern Nigeria. *African Journal of Biotechnology*, 8, 4923-4932.
Samaila, J., Nwabueze, T.U., Onwuka, G.I., Ndife, J. and Usman, M.A. (2020). Chemical and nutritional composition of some selected lesser-known

legumes indigenous to Nigeria. *Heliyon*, 6(1): 05497.

Sandhu K., Singh, N. and Malhi, N. (2007). Some properties of corn grains and their flours I: Physicochemical, functional and chapatti making properties of flours. *Food Chemistry.,* 101 (3), 938-946.DOI: 10.1016/j. foodchem.2006.02.040

Shrivastava, C. and Chakraborty, S. (2018). Bread from wheat flour partially replaced by fermented chickpea flour: Optimizing the formulation and fuzzy analysis of sensory data. *LWT*, 90, 215-223. https://doi.org/10.1016/j.lwt.2017.12.01.

Small, D. and Prescott J. (2005). Odor/taste integration and the perception of flavor. Expert *Brain Research*, 166(3 & 4), 345-357. DOI: 10.1007/s00221-005-2376-9

Sokrab, A. M., Mohamed A. Isam, A. and Babiker, E. (2012). Effect of germination on antinutritional factors, total, and extractable minerals of high and low phytate corn (*Zea mays* L.) genotypes. *Journal of the Saudi Society of Agricultural Sciences,* 11: 123–128.

Suresh, C., Samsher S. and Durvesh, K. (2015). Evaluation of the functional properties of composite flours and sensorial attributed of composite flour biscuits. *Journal of Food Science & Technology,* 52(6): 3681-3688.

Tenagashaw, M. W., Kenji, G. M., Melaku, E. T., Huyskens-Keil, S. and Kinyuru, J. N. (2015). Proximate composition & selected functional properties of complementary foods from teff fortified with soybean and orange-fleshed sweet potato. *RUFORUM Working Document Series* (ISSN 1607-9345) No. 14 (1): 953-965.

Thakur, P., Kumar, K., Ahmed, N., Chauhan, D., Rizvi, Q.U.E.A., Jan, S. Singh, T.P. and Dhaliwal, H.S. (2021). Effect of soaking and germination treatments on nutritional, anti-nutritional, and bioactive properties of amaranth (*Amaranthus hypochondriacus* L.), Quinoa (*Chenopodium quinoa* L.) and buckwheat (*Fagopyrum esculentum* L.). *Current Research in Food Science*, 4:917-925.

Trease, G. E., & Evans, W. C. (1978). *A Text Book of Pharmacognosy*. 11ed.BailliereTindall, London.

Vasishtha, H. and Srivastava (2013). Effect of soaking and germination on dietary fiber constituents of chickpea (*Cicer Arietinum). Legume Research*, 36(2):174-179.

Woolfe, J. (1992). *Sweet potato: An Untapped Food Resource* (Vol. 366-372,). Cambridge University Press Pp. 1-13.

World Health Organization. (2001). *Iron deficiency anaemia: Assessment, prevention and control: A guide for programme managers*. Geneva, WHO.

Table 1: Blending ratios of germinated rice and pigeon pea flours (%)

Sample Codes	Un-germinated Rice Flour (%)	Germinated Rice Flour (%)	Germinated Pigeon Pea Flour (%)
URF (control)	100	0	0
GRF	0	100	0
50GRF:50GPF	0	50	50
60GRF:40GPF	0	60	40

Table 2: Recipe table for germinated rice-pigeon pea flour-based breakfast meals.

Ingredients	Amount (g)
Flour	250g
Sugar	50g
Salt	2g
Flavor	5ml
Water	130ml

Table 3: Functional properties of rice-pigeon pea composite flours

Samples	BD (g/ml)	WAC (g/g)	SI (g/ml)	GT (°C)
100%URF	$0.75^{c} \pm 0.07$	$2.73^{a} \pm 0.08$	$1.93^{c} \pm 0.02$	$76.70^{d} \pm 0.03$
100%GRF	$0.83^{b} \pm 0.04$	$1.83^{d} \pm 0.12$	$1.31^{d} \pm 0.05$	$78.20^{c} \pm 0.05$
50%GRF:50%GPF	$0.88^{a} \pm 0.05$	$2.21^{c} \pm 0.10$	$2.26^{b} \pm 0.03$	$80.65^{a} \pm 0.02$
60%GRF:40%GPF	$0.83^{b} \pm 0.03$	$2.34^{b} \pm 0.14$	$2.41^{a} \pm 0.02$	$79.85^{b} \pm 0.00$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly (p<0.05) different. Keynote: BD-Bulk density, WAC- Water absorption capacity, SI - Swelling index, GT- Gelatinization temperature. URF – control (Un-malted rice flour), GRF - Malted rice flour, GPF- Malted pigeon pea flour

Table 4: Pasting properties of rice-pigeon pea flour blends

Samples	100% URF	100%GRF	50%GRF:50%GPF	60%GRF:40%GPF
Peak Viscosity (RVU)	513.92^{a} ± 0.50	490.33^{b} ± 0.20	254.00^{d} ± 0.50	313.90^{c} ± 0.71
Trough I (RVU)	385.25^{d} ± 0.12	289.50^{c} ± 0.41	158.00^{a} ± 0.54	263.67^{b} ± 0.73
Breakdown (RVU)	174.67^{d} ± 0.36	100.83^{c} ± 0.50	76.00^{a} ± 0.35	90.25^{b} ± 0.24
Final viscosity (RVU)	533.08^{c} ± 0.83	418.75^{d} ± 0.71	302.33^{a} ± 0.87	326.42^{b} ± 0.60
Setback visc. (RVU)	127.83^{b} ± 0.51	129.25^{b} ± 0.25	164.33^{a} ± 0.15	160.75^{a} ± 0.50
Peak time (min)	4.13^{a} ± 0.02	4.25^{a} ± 0.01	4.80^{c} ± 0.02	4.67^{b} ± 0.05
Pasting Temp.(^{o}C)	77.7^{a} ± 0.01	78.9^{b} ± 0.00	80.6^{d} ± 0.02	79.2^{c} ± 0.02

Values are means ± standard deviation of duplicate determinations. Mean values across the same row with different superscripts are significantly different (p<0.05). Keynote: URF (Un-germinated rice flour), GRF (germinated rice flour) , GPF (germinated Pigeon pea flour)

Table 5: Proximate composition of Rice-Pigeon base breakfast cereal

Components	100% URF	100% GRF	50% GRF:50%GPF	60%GRF:40%GPF
Moisture content (%)	7.84^{a} ± 0.04	4.74^{d} ± 0.04	5.35^{c} ± 0.04	5.93^{b} ± 0.03
Crude protein (%)	6.97^{d} ± 0.03	9.15^{c} ± 0.02	20.09^{a} ± 0.02	16.81^{b} ± 0.02
Crude fibre (%)	1.43^{c} ± 0.03	0.85^{d} ± 0.02	1.78^{a} ± 0.02	1.66^{b} ± 0.02
Fat (%)	1.52^{a} ± 0.02	1.06^{d} ± 0.02	1.25^{b} ± 0.02	1.18^{c} ± 0.01
Ash (%)	2.49^{d} ± 0.02	2.98^{c} ± 0.01	3.38^{a} ± 0.01	3.20^{b} ± 0.02
Carbohydrate (%)	79.75^{b} ± 0.02	81.22^{d} ± 0.04	68.15^{d} ± 0.01	71.22^{c} ± 0.01

Values are means ± standard deviation of duplicate determination. Mean values in the same row with different superscripts are significantly different (p<0.05). Where; URF = Un-germinated rice flour, MRF = Germinated rice flour and MPF = Germinated Pigeon pea flour

Table 6: Mineral Composition of the breakfast meals

Samples	Calcium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)
100% URF	24.02^{d} ± 0.02	10.33^{d} ± 0.03	1.15^{d} ± 0.02
100% GRF	40.35^{c} ± 0.01	13.53^{c} ± 0.02	1.37^{c} ± 0.05
50%GRF:50%GPF	53.65^{a} ± 0.03	29.62^{a} ± 0.05	1.95^{a} ± 0.01
60%GRF:40%GPF	48.11^{b} ± 0.02	24.36^{b} ± 0.02	1.71^{b} ± 0.03

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (p<0.05). Where; URF = Un-germinated rice flour, GRF = germinated rice flour and GPF = germinated Pigeon pea flour

Table 7: Anti-nutritional properties of germinated rice-pigeon pea-based breakfast cereal

Samples	Trypsin inhibitor (TIU/g)	Tannin (mg/100g)	Phytate (mg/100g)
100% URF	4.82^{c} ± 0.03	1.87^{c} ± 0.01	8.50^{a} ± 0.28
100% GRF	1.17^{d} ± 0.02	0.41^{d} ± 0.02	2.13^{d} ± 0.03
50%GRF:50%GPF	7.34^{a} ± 0.04	2.14^{a} ± 0.05	5.95^{b} ± 0.02
60%GRF:40%GPF	6.32^{b}± 0.07	2.02^{b} ± 0.02	5.28^{c} ± 0.05

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (p<0.05). Where; URF= un-germinated rice flour, GRF= Germinated rice flour, GPF= Germinated pigeon pea flour

Table 8: Sensory properties of germinated rice-pigeon pea-based breakfast meal

Samples	Appearance	Taste	Texture	Aroma	Overall acceptability
100% URF	7.65^{b} ± 0.81	7.60^{b} ± 1.54	7.10^{b} ± 1.74	7.75^{a} ± 1.02	7.90^{b} ± 1.02
100% GRF	7.75^{a} ± 1.07	8.00^{a} ± 0.97	7.65^{a} ± 1.35	7.75^{a} ± 1.16	8.15^{a} ± 1.04
50% GRF:50%GPF	6.26^{c} ± 1.94	5.10^{d} ± 2.20	5.30^{d} ± 2.15	5.75^{c} ± 1.86	5.75^{d} ± 1.86
60% GRF:40%GPF	5.55^{d} ± 1.88	5.79^{c} ± 1.93	5.58^{c} ± 2.22	5.89^{b} ± 2.00	6.16^{c} ± 2.17

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscripts are significantly different (p<0.05). Where; URF = Un-germinated rice flour, GRF= Germinated rice flour, GPF = Germinated pigeon pea flour