*Asian Food Science Journal*

***20(8): 52-65, 2021; Article no.AFSJ.70406***
***ISSN: 2581-7752***

# Production and Evaluation of Breakfast Meals from Germinated and Ungerminated Blends of Sorghum and Soybean by Cold Extrusion Process

**D. B. Kiin-Kabari[1], Anijekwu, Prisca Obiageli[1*] and J. Eke-Ejiofor[1]**

*[1]Department of Food Science and Technology River State University, Port Harcourt, River State. Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AFSJ/2021/v20i830330
Editor(s):
(1) Dr.Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.
Reviewers:
(1) Tejaswi Boyapati, Vignan's Foundation for Science, Technology and Research Institute, India.
(2) Boru Asefa Mosissa, Wollega University, Ethiopia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/70406

***Original Research Article***

***Received 28 April 2021***
***Accepted 03 July 2021***
***Published 08 July 2021***

## ABSTRACT

Breakfast meal was formulated from blends of sorghum and soya beans. The mixed blends of (ungerminated and germinated sorghum/soyabean flour blends) was produced into S-shaped granules using a cold extruder in the following formulation ratio of 100:0, 90:10, 80:20, 70:30,and 60:40 ratio. Proximate composition, total mineral (Magnesium, phosphorous, potassium calcium, iron and Zinc), extractable mineral and mineral bio-availability were carried out on the finished product of different blends. Germinated products showed lowest moisture(7.99 %) and carbohydrate(59.43 %) contents, and high values of Ash (3.64 %), Protein(18.19 %) and fat (8.99 %) contents. The highest value Fiber and Energy were obtained in the ungerminated products with values of 11.22 % and 355.72 %, respectively.Bioavailability of germinated product blends showed higher values for all the minerals analyzed.Onsensory evaluation, the ungerminated sorghum product (100:0) recorded highest values among the samples analyzed and was most preferred in term of colour (4.35) and taste (4.10) while the germinated products received preference in the texture with a highest value of 4.35. The overall acceptability was recorded in the ungerminated products with the highest value of 4.15. The results showed that germination and substitution with soya bean up to 60:40 increased the nutrient content of breakfast meal.

**Corresponding author: Email: obiagelianijekwu@gmail.com;*

*Keywords: Breakfast meal; proximate; minerals; bioavailability; sensory.*

## 1. INTRODUCTION

Breakfast meal is the first meal of the day that breaks the fast after the longest period of sleep and is consumed within 2 to 3 hours of waking; it could be food or beverage from at least one food group and may be consumed at any location [1]. Research shows that those individuals who have breakfast on a regular basis have a more balanced overall diet with nutrient and food selection that can fulfill their nutritional recommendations [2]. Composite flour utilization in recent past from crops such as cassava, cocoyam, sweet potato, sorghum and millet for bakery products has gained prominence in many countries which traditionally import intermediate foods such as wheat flour for this purpose. Flour from these root and tuber crops have been used in the production of bread, cookies, doughnuts and noodles [3] [4]. Their uses and benefits in the preparation of products such as biscuits and cakes have been extensively studied [5] [6] [7]. The choice of cereals and legumes in these blends is chiefly attributed to the complementary nature of the proteins in these cereal- legume blends that provide significant levels of essential amino acids [8] [9]. The use of a variety of local food ingredients which are rich sources of micronutrients in food preparations in comparison to other interventions has proven to be a viable and sustainable approach in tackling all forms of malnutrition in addition to promoting food security in the long term [10]. Their diversification beyond the traditional food cuisines and potential uses in alternative product development such as breakfast meal and snack food has also attracted much attention. Sorghum can thrive under adverse climate conditions and can consistently produce crop under climate conditions where other cereal fail.

In Nigeria sorghum is among the most important cereal crop in the order of needs. However, a well identified and important problem relating to the nutritional value of sorghum is that the protein of cooked sorghum is significantly less digestible than that of other cooked cereal [11] since cereals are invariably cooked prior to consumption; the lower digestibility of sorghum protein militates significantly against the use of this cereal. However, malting has been identified as a traditional processing technology that could possibly be used to improve the nutritional quality of the protein [12]. Akinnele and Edwards [13] reported the fortification of ogi with legumes, vitamins and minerals. Improvement in the technology of ogi has led to the development of soya-ogi, a combination of maize and soya-beans. Soya-beans has a high protein content of about 44 % and carbohydrate content of about 18 % [14], however the major limiting factor of soya beans in its processing is the flavour [15]. Soya beans also known as edamane beans when eaten fresh from the pod are consumed as an alternative to meat. It is now the most widely grown and utilized legume worldwide Since the 1970s, there has been a marked increase in the consumption of traditional soya foods and the development of other soya foods which stimulated traditional meat and dairy products such as soya milk, soya sausages, soya cheese and soya yoghurts.

## 2. MATERIALS AND METHODS

### 2.1 Sample Preparation

Germinated and ungerminated sorghum seeds were subjected to pre gelatinization with the aim of identifying the treatment that will impact some desirable quality characteristics.

### 2.2 Processing of Ungerminated Pre-gelatinized Sorghum Flour

The purchased sorghum grain was prepared into sorghum flour using the method described by Mgbeyi, [16]. The sorghum grain was properly cleaned and sorted to remove the insect-infested grains, damaged seeds, husks, stones, sticks, leaves and soil. The cleaned whole grains were cracked using a disc attrition mill (Bentall. Superb Model 200L, 090 Germany) to produce grits. The grits was moistened with water and heated in a Gallenkarnp water bath at temperatures (60°C) for 50-60 minutes to estimate the optimal gelatinization conditions. The pre gelatinized grits was dried at 55°C for 24hours and mill in a hammer mill.

### 2.3 Production of Germinated Pre-Gelatinized Sorghum Flour

The sorghum grain was cleaned to remove extraneous materials, cleaned sorghum grains was steeped for 24 hours wet steep at temperature of $28^{o}C \pm 2^{o}C$ for the grain to imbibe water as solvent according to Etok Akpan and Palmer (1990) as described by Mgbeyi, [16] with some modification. The soaked grain was allowed to sprout for 5 days at room temperature of 28$^o$C (to induce growth of seedlings, then dry at temperature of 55$^o$Cfor 24hours in a conventional oven to remove moisture, kilning at 85$^o$C for 4hours in a hot air oven to facilitate further drying of the sprouted grain, the rootlets and coleoptiles was removed (devegetation) sorted, the cleaned whole grains was cracked using a disc attrition mill (Bentall. Superb Model 200L, 090 Germany) to produce grits. The grits was moistened with water and heated in a Gallenkarnp water bath at temperatures (100°C) for 50-60 minutes to pre- gelatinize the grit. The pre-gelatinized grits was dried at 55°C for 24hours and mill in a hammer mill and designated as germinated pre-gelatinized sorghum flour.

## 2.4 Moisture Content

The method described by AOAC [18] was used to determine the moisture content. Five grams of each sample was weighed into a petri dish and dried to constant weight at 105± 2°C then calculated thus:

$$\% \text{ Moisture} = \frac{Loss\ in\ weightofsample\ (g)}{weightofsample\ (g)} \times 100$$

## 2.5 Determination of Ash

Crucibles were washed and dried in the oven, allowed to cool in a desiccator, and weighed. 3 g of dry sample (starch) was weighed in empty porcelain crucibles of known weight as described by AOAC [18]. The crucibles were placed on a hot plate under a fume cupboard to char organic matter. The crucibles were then placed inside a muffle furnace (Fisher Isotherm Muffle Furnace, model 186A, USA) at a temperature of 550ºC for 8 hours. The crucibles were transferred to a desiccator to cool for one hour. The crucibles plus ash were then weighed and the weight of ash calculated as:

$$\% \,\mathbf{Ash} = \frac{weightofash\ (g)}{weightofsample\ (g)} \times 100$$

## 2.6 Determination of Crude Protein

Using the method described by AOAC [18], the following process was adopted.

**Digestion:** Zero point five grams (0.5 g) each of sample were weighed carefully into a 500 mLKjeldah digestion tubes. To each was selenium tablet added as catalyst plus 20 mL of Conc $H_2SO_4$. It was swirled and heated in a fume cupboard until a clear liquid will be obtained.

**Distillation:** The distillation was carried out using Markham Distillation Apparatus which allows volatile substance to be steam distillate. Made up sample (10 mL) was pipette into the apparatus through the same opening by gently and carefully removing the stopper to prevent suck back. The mixture was steam-distilled for 2 minutes into 50 mL conical flask containing Boric Acid (10 mL of 2 %) as indicator, which changes the colourless acid to yellow colour. This was placed at the receiving tip of the condenser. The Boric Acid plus indicator solution would change colour from yellow to bluish green showing that all the ammonia liberated has been trapped.

**Titration:** This bluish green colour solution obtained was titrated against HCL (0.0IN) until the colour after the indicator will be added and obtained that is until colour change from bluish green to light yellow, which indicates that all the Nitrogen trapped as Ammonium Borate $(NH_4)_2BO_{3)}$ has been remove as Ammonium chloride ($NH_4CL$).

The percentage nitrogen and crude protein were calculated as:

$$Percentage\ Nitrogent = \frac{Titre\ Value\ (0.00) \times 14 \times 10 \times 100}{Weight\ of\ \ Sample}$$

Percentage Crude Protein = % Nitrogen x 6.25
Where 6.25 = conversion factor

## 2.7 Determination of Carbohydrates

The Nitrogen free method described by AOAC [19] was used. The carbohydrate was calculated as weight by difference between 100 and the summation of other proximate parameters as Nitrogen free extract (NFE) percentage carbohydrate.

$$\%\, carbohydrate = 100 - (M + P + F + A + F2)$$

**Where:**
M = Moisture
P = Protein
F = Fat
A = Ash
$F_2$ = Crude fibre

**List 1. Formulation Table for Sorghum/ Soya Bean Flour Blends**

| Blend | Sorghum (%) | Soya beans (%) |
|---|---|---|
| USSFA(Control) | 100 | 0 |
| USSF B | 90 | 10 |
| USSF C | 80 | 20 |
| USSF D | 70 | 30 |
| USSF E | 60 | 40 |
| GSF F | 100 | 0 |
| GSSF G | 90 | 10 |
| GSSF H | 80 | 20 |
| GSSF I | 70 | 30 |
| GSSF J | 60 | 40 |

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF B - (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C - (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D - (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E - (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSF F - (100:0) Germinated Sorghum Flour*
*GSSF G - (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H - (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I - (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

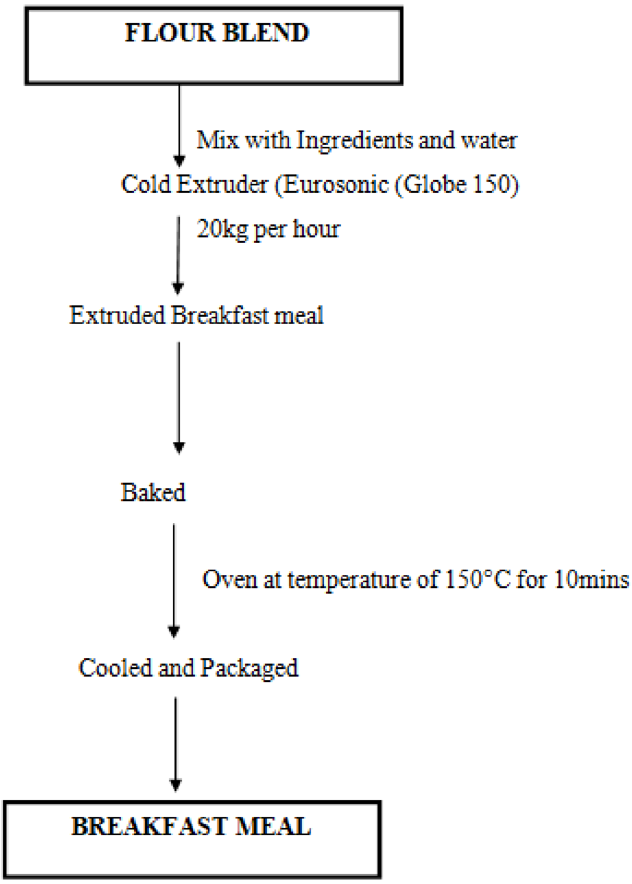


**Fig. 1. Production of Breakfast meal from Blends Sorghum and Soya Beans Flour as described by Kiin-Kabari *et al.* [17]**

### 2.8 Determination of Total Fat by Manual Extraction (Official Method of Analysis of AOAC [18]

Fats were determined using the Soxhlet extraction apparatus [18]. Approximately 1g of moisture-free starch sample was wrapped in filter paper, placed in a fat-free thimble, and introduced into the extraction tube. A weighed, clean and dried receiving beaker was filled with petroleum ether and fitted into the apparatus. Water and heater were turned on to start extraction. After siphoning 4-6 times, the ether was allowed to evaporate and the beaker were disconnected before the last siphoning. The extract was transferred into a clean glass dish with ether washing and evaporated water on water bath. The dish was placed in an oven at 105 for 2 hours and cooled in a desiccator. The percentage of fat was determined thus:

$$Fat\ (\%) = \frac{Weightofetherextract}{Weightofsample} \times 100$$

### 2.9 Determination of Crude Fibre

0.5g of starch sample ($W_0$) were weighed and transferred to a porous crucible, which was then placed in a Dosi-fiber unit, with the valve kept in an “OFF” position. Then, 150 mL of preheated $H_2SO_4$ solution and a few drops of foam suppresser were added to each column. Then the cooling circuits were opened and the heating elements were turned on with power at 90 %. When the solution begins to boil, the power was reduced to 30 % and left for 30 minutes. Valves were opened for acid drainage and rinsed thrice with distilled water to ensure the removal of acid from the sample. The samples were oven-dried at 150℃ for 1 hour. It was allowed to cool in a desiccator and then weighed ($W_1$). The sample crucibles were kept in a muffle furnace at 550℃ for 3-4 hours. The samples were cooled in a desiccator and weighed again ($W_2$) described by AOAC (2012). The percentage of crude fiber was determined thus:

$$\textbf{Crude fiber}\ (\%) = \frac{W_1 - W_2}{W_0} \times 100$$

### 2.10 Determination of Minerals

The determination of the mineral compositions of the samples was done according to the method described by AOAC [18]. The total mineral content (iron, calcium, sodium, and potassium) were determined. One (1) g of the sample was weighed into a crucible and sent into a muffle furnace at $550^0$C for 4h until the color of the ash turned grey white indicating complete oxidation of all organic matter in the sample. The crucible and the ash were left to cool in a desiccator and then 10 mL of 0.1N HCl (Larbo Chemie, Germany) was added in other to dissolve ashes. The solution was filtered using Whatman filter paper No 1 (Sigma Aldrich, South Africa) and the filtrate was used for mineral quantification using Atomic Absorption Spectrophotometer (Thermo Scientific, USA). The concentration of the minerals was read in mg/L and calculated as follows:

$$Mineral \left(\frac{mg}{100g}\right) = Concentration\ (ppm) \times \frac{Solution\ Volume}{10\ \times Sample\ Weight} \times 1000$$

### 2.11 Determination of Phosphorus

10 mL of 0.1 mg/ mL phosphate standard solution (to obtain 1 mg P) and 5 mL of test solution was pipetted into 100 mL volumetric flask respectively, to each flask 10 mL of 6N $HNO_3$, 10 mL of 0.25 % ammonium monovanadate and 10 mL of 5 % ammonium molybdate was added, the solutions was diluted to mark with demonized water Mixed well and stood for exactly 15 minutes to allow complete color development. The absorbance of each solution in 1cm cell at 400 nm was measured with UV-VIS spectrophotometer using reagent blank for auto zero. Phosphorus was calculated using the formula:

$$P\ mg100^{-1}\ g = \frac{Abs_{sam} \times 1 \times V_0 \times 100}{Abs_{std} \times V_p \times W}$$

Where:
$Abs_{sam}$ = absorbance sample,
Absstd = absorbance standard (1mg/ mL)
Vo = total volume ( mL),
Vp = volume of diluted sample ( mL) and W = sample weight (g)
Test results was reported in mg per 100 g sample,

### 2.12 Determination of Calcium, Magnesium, Potassium Zinc and Iron

**Standard preparation:** 1 mL certified Calcium, Magnesium, Potassium or Iron Standards was pipetted into a 50 mL volumetric flask (each) and diluted to volume with 1N HNO3, the solution was mixed by slowly inverting the flask 10 times, from the working standard 0.4, 0.8, 1.2, 1.6, and 2.0 µg/mL calibration standards will be prepared.

**Test solution:** 10 mL of the prepared test sample was pipetted into a 50 mL volumetric flask and made up with 1N $HNO_3$. The absorbance of the prepared standards and test solutions was measured with Atomic Absorption Spectrophotometer (AAS) against reagent blank (calcium at 422.7 nm, magnesium at 285.2 nm, Iron at 248.3 nm, Sodium at 589.0 nm, Manganese at 285.21 nm, Zinc at 213.9 nm and Potassium at 766.5 nm). The measurement was carried out according to the following order: water, reagent blank (0 ppm, to set zero), sample blank, standards (from the lowest concentration to the highest), and test solution. The system was washed with water after reading each test solution. Calcium, Magnesium or Iron was calculated using the expression:

$$Ca, Fe, K, or\ Mg\ (\text{mg/100g}) = \frac{C_0 \times total\ volume(ml) \times dilution \times 100}{weight\ of\ sample(g) \times P \times 1000}$$

Where:
$C_0$= concentration of the sample in mg/L from the calibration curve (mg/L)
P= sample solution taken, mL

## 3. Mineral Extractability

Hydrochloric acid extractability of minerals was performed according to the Chauhan and Mahjan [20] method. About 1.0g was extracted using 10 mL of 0.03N HCL with shaking at 37°C for 3 hours. Thereafter, the extract was filtered and the clear filtrate obtained was dried at 100°C and then placed in a muffle furnace at 550°C for 4 hours. Thereafter, the sample were cooled and about 5 mL of 5N HCL were added and boiled gently for 10 minutes and then cooled and diluted to 100 mL with distilled water. Mineral were determined as described above.

$$Mineral\ extractibillity(\%) = \frac{Mineral\ extractibilty\ in\ 0.05Hcl}{Total\ mineral\ content} \times 100$$

### 3.1 Sensory Characteristics of Breakfast Meal

Method described by Giami and Barber [21] for fluted pumpkin cookies was used. Semi-trained panel of twenty consumers comprising of staff, Interns and Corpers of NAFDAC Area Laboratory Port Harcourt, Nigeria were used. At each session, the five samples were served on a transparent white glass cup and labeled accordingly (A, B, C, D, E. F .G. H. I. J.). Panelists were instructed to evaluate color first and then taste each sample to evaluate taste and texture. The semi-panelists were required to assign scores based on the crunchiness of the sample using 5-point hedonic scale. The overall acceptability was then calculated from the given parameters. Evaluation was carried out on the same day of production after cooling.

### 3.2 Color

The samples were placed in a white saucer and observed by panelists under a well light. The evaluators enter the test room in batches of five, each occupying a table and a seat. The light in the room was adequate to ensure that the product was well lit. Color evaluation was done based on a 5-point hedonic scale with 5= Extremely brown, 4= Slightly brown, 3= Moderately brown, 2= Brown, 1= Dark.

### 3.3 Taste

Samples were served with already mixed 100 mL in 1000 mL milk: water in a labelled transparent glass cup and panelist required to evaluate the samples based on their perception of each sample in terms of taste. A bottle of water was provided for rinsing mouth before and after each sample. Panelists were required to record their preference using the provided 5-point hedonic scale 5= Very sweet, 4= Sweet, 3= Slightly sweet, 2= Bland, 1= Neither sweet nor bland.

### 3.4 Texture/Crispiness

The texture of the samples was rated based on their crunchiness. The semi-panelists were required to assign scores based on the crunchiness of the sample using 5-point hedonic scale 5= Extremely crunchy, 4= Very crunchy, 3= Moderately crunchy, 2= Slightly crunchy, 1= Neither crunchy nor soft. The evaluators were required to take a bite at the sample by evaluating the force required to penetrate the sample using the incisor and further compress the sample using the molars and record the score.

### 3.5 Overall Acceptability

The overall acceptability was calculated based on the average scores of the parameters of individual sample.

### 3.6 Statistical Analysis

The data obtained for all the analysis carried out were subjected to statistical analysis using the software SPSS for window version 21.0 statistical package (SPSS Inc.) using complete randomized design and the significant difference between the means analyzed using Duncan Multiple Range test. All statistical tests were performed at 5 % significant level.

## 4. RESULTS AND DISCUSSION

### 4.1 Proximate Composition of Value-added Products

Moisture content of the ungerminated product samples decreased (9.06 % to 8.74 %) with Soyabean substitution. This value is higher than those obtained by Obasi and Ifediba (2018) from biscuit made from African breadfruit, Maize and Coconut flour. A reverse effect (8.37 % to 9.74 %) was obtained in the germinated sample products and their values are slightly higher from those of Eke-Ejiofor and Williams [22] in rice-based biscuit production with inclusion of defatted soya flour. These values are in agreement with work reported by Okoronkwo *et al.,* [23] ranged from 6.61 % to 10.92 %. The moisture content of the product show a slight increase to that of flour blends, this could be due ingredients added in the production of the breakfast meal. Although the germinated products have higher moisture content than the ungerminated products, they are within the recommended range of 14 % max AACC, [19]. Sanni *et al*. [24] reported that the lower the moisture of a product to be stored the better the shelf stability of such product. The Ash content of the germinated products decreased from 3.67 % to 2.54 % and these values were lower than those obtained from the ungerminated products. The trend is in accordance with the work of Mbaeyi [16], that sprouting decreased the ash content of composite flour of peageon pea and Sorghum in production breakfast cereal. The fat content of the ungerminated product samples increased with substitution with soya bean (0.79 % -3.18 %). Adegunwa *et al.* [25] observed similar increase in fat content in inclusion of soy flour with carrot powder for noodles production. There was also a gradual increase in the fat content of products with increase in soya bean incorporation in the germinated product samples. Soya bean is rich in healthyand contains appreciable amount of minerals and fat. Also, fat acts as flavors returner and help to improve sensory qualities of baked products. Zegeye *et al,* [26] reported high value for cookies with higher soybean than other product.

**Table 1. Proximate composition of extruded breakfast meal (%)**

| | Moisture | Ash | Fat | Protein | Fibre | CHO | Energy (Kcal) |
|---|---|---|---|---|---|---|---|
| A | 9.06$^{abc}$±0.31 | 3.38$^{abc}$±0.19 | 0.79$^{b}$±0.00 | 7.37$^{h}$±0.52 | 11.22$^{a}$±0.13 | 68.19$^{a}$±0.24 | 309.33$^{e}$±1.50 |
| B | 9.02$^{abc}$±0.01 | 2.79$^{cd}$±0.43 | 2.39$^{a}$±0.00 | 10.39$^{f}$±0.00 | 10.18$^{b}$±0.00 | 65.24$^{bc}$±0.42 | 324.11$^{d}$±1.58 |
| C | 8.27$^{cd}$±0.40 | 3.21$^{bc}$±0.02 | 2.60$^{a}$±0.00 | 11.26$^{e}$±0.00 | 10.15$^{b}$±0.00 | 64.62$^{cd}$±0.57 | 326.92$^{d}$±2.26 |
| D | 8.66$^{bcd}$±0.28 | 3.85$^{ab}$±0.01 | 2.78$^{a}$±0.00 | 14.73$^{c}$±0.00 | 6.53$^{e}$±0.00 | 63.46$^{d}$±0.13 | 337.76$^{b}$±0.54 |
| E | 8.74$^{bcd}$±0.38 | 3.91$^{a}$±0.00 | 3.18$^{b}$±0.87 | 18.19$^{a}$±0.00 | 2.38$^{g}$±0.30 | 63.60$^{d}$±0.80 | 355.72$^{a}$±4.63 |
| F | 8.37$^{cd}$±0.00 | 3.67$^{ab}$±0.00 | 0.80$^{a}$±0.01 | 8.99$^{g}$±0.00 | 10.96$^{a}$±0.00 | 67.21$^{a}$±0.28 | 311.69$^{e}$±0.69 |
| G | 7.99$^{d}$±0.18 | 2.54$^{d}$±0.07 | 2.48$^{a}$±0.07 | 10.83$^{ef}$±0.62 | 10.16$^{b}$±0.00 | 66.00$^{b}$±0.00 | 329.62$^{cd}$±3.99 |
| H | 9.41$^{ab}$±0.21 | 3.21$^{bc}$±0.00 | 2.80$^{a}$±0.56 | 12.99$^{d}$±0.00 | 9.55$^{c}$±0.11 | 62.04$^{e}$±0.17 | 325.28$^{d}$±5.71 |
| I | 9.29$^{ab}$±0.00 | 3.63$^{ab}$±0.18 | 3.07$^{a}$±0.13 | 15.59$^{b}$±0.00 | 6.86$^{d}$±0.00 | 61.56$^{e}$±0.47 | 336.19$^{bc}$±3.08 |
| J | 9.74$^{a}$±0.84 | 3.64$^{ab}$±0.66 | 3.16$^{a}$±0.00 | 18.19$^{a}$±0.00 | 5.84$^{f}$±0.14 | 59.43$^{f}$±0.99 | 338.92$^{b}$±3.96 |

*Mean values are of duplicate determinations. Values within a column with the same superscript are not significantly different (p>0.05*

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF B - (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C - (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D - (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E - (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSSF F - (100:0) Germinated Sorghum Flour*
*GSSF G - (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H - (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I - (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

**Table 2.Total mineral of extruded breakfast meal (mg/100g)**

| Samples | Magnesium | Phosphorous | Potassium | Calcium | Iron | Zinc |
|---|---|---|---|---|---|---|
| A | $68.58^{i}$±.0.31 | $11.49^{d}$±0.01 | $847.52^{d}$±0.03 | $91.46^{e}$±0.00 | $41.72^{j}$±0.00 | $5.10^{de}$±0.00 |
| B | $69.15^{h}$±.0.00 | $10.60^{f}$±0.00 | $763.61^{f}$±0.00 | $86.42^{f}$±0.03 | $44.65^{i}$±0.38 | $5.05^{e}$±0.07 |
| C | $70.99^{f}$±.0.14 | $9.81^{g}$±0.01 | $712.98^{h}$±0.13 | $84.28^{g}$±0.41 | $51.44^{h}$±0.00 | $5.05^{e}$±0.00 |
| D | 71.78e±.0.00 | $7.96^{h}$±0.00 | $507.32^{i}$±0.03 | $83.99^{g}$±0.72 | $56.03^{g}$±1.19 | $4.11^{f}$±0.04 |
| E | $73.68^{d}$±.0.11 | $7.32^{i}$±0.03 | $310.92^{j}$±0.03 | $71.72^{h}$±0.03 | $68.84^{d}$±0.21 | $4.02^{f}$±0.03 |
| F | $70.01^{g}$±.0.01 | $15.28^{a}$±0.00 | $913.56^{a}$±0.00 | $107.67^{a}$±0.30 | $58.52^{f}$±0.03 | $6.33^{a}$±0.04 |
| G | $73.86^{d}$±.0.06 | $14.11^{b}$±0.16 | $902.73^{b}$±0.40 | $104.77^{b}$±0.00 | $64.78^{e}$±0.00 | $6.10^{b}$±0.00 |
| H | $76.67^{c}$±.0.00 | $13.01^{c}$±0.01 | $859.02^{c}$±0.03 | $101.32^{c}$±0.03 | $69.78^{c}$±0.40 | $5.76^{c}$±0.00 |
| I | $78.13^{b}$±.0.18 | $11.10^{e}$±0.00 | $786.13^{e}$±0.20 | $94.00^{d}$±0.00 | $75.65^{b}$±0.07 | $5.66^{c}$±0.08 |
| J | $80.68^{a}$±.0.00 | $11.01^{e}$±0.01 | $752.72^{g}$±0.00 | $93.71^{d}$±0.01 | $98.95^{a}$±0.00 | $5.20^{d}$±0.07 |

*Mean values are of duplicate determinations. Values within a column with the same superscript are not significantly different (p>0.05*

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF B - (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C - (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D - (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E - (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSSF F - (100:0) Germinated Sorghum Flour*
*GSSF G - (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H - (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I - (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

**Table 3. Mineral Extractability of Extruded Breakfast Meal (mg/100g)**

| Sample | Magnesium | Phosphorous | Potassium | Calcium | Iron | Zinc |
|---|---|---|---|---|---|---|
| A | $39.87^{h}$±0.00 | $7.12^{d}$±0.17 | $460.22^{d}$±0.08 | 55.32f±0.45 | $19.00^{i}$±0.00 | $1.22^{f}$±0.00 |
| B | $40.33^{g}$±0.47 | $6.00^{f}$±1.03 | $389.00^{g}$±1.41 | $48.32^{g}$±0.24 | $20.59^{h}$±0.03 | $1.06^{g}$±0.06 |
| C | $42.10^{f}$±0.00 | $4.89^{g}$±0.01 | $354.00^{h}$±0.00 | $42.32^{h}$±0.00 | $22.57^{g}$±0.00 | $1.20^{f}$±0.00 |
| D | $45.11^{e}$±0.16 | $3.06^{h}$±0.08 | $247.12^{i}$±0.00 | $42.10^{h}$±0.14 | $29.67^{f}$±0.13 | $0.97^{h}$±0.00 |
| E | $50.11^{b}$±0.00 | $2.60^{i}$±0.07 | $147.12^{j}$±0.00 | $35.10^{i}$±0.14 | $37.67^{d}$±0.66 | $0.94^{h}$±0.01 |
| F | $45.00^{e}$±0.00 | $10.71^{a}$±0.04 | $665.76^{a}$±0.28 | $68.22^{a}$±0.00 | $32.00^{e}$±0.00 | $1.98^{a}$±0,00 |
| G | $45.78^{d}$±0.03 | $9.8\ 5^{b}$±0.18 | $544.23^{b}$±0.16 | $65.22^{b}$±0.31 | $37.66^{d}$±0.01 | $1.80^{b}$±0,01 |
| H | $48.00^{c}$±0.00 | $7.89^{c}$±0.06 | $494.00^{c}$±0.00 | $62.26^{c}$±0.00 | $42.66^{c}$±0.00 | $1.46^{c}$±0.06 |
| I | $50.01^{b}$±0.01 | $6.44^{e}$±0.03 | $447.01^{e}$±0.01 | $57.02^{d}$±0.03 | $48.68^{b}$±0.00 | $1.40^{d}$±0.00 |
| J | $50.57^{a}$±0.00 | $6.14^{f}$±0.00 | $420.21^{f}$±0.00 | $56.00^{e}$±0.00 | $65.60^{a}$±0.03 | $1.29^{e}$±0.00 |

*Mean values are of duplicate determinations. Values within a column with the same superscript are not significantly different (p>0.05*

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF - (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C- (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D- (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E- (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSSF F - (100:0) Germinated Sorghum Flour*
*GSSF G- (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H- (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I- (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

There was no significance difference between the protein values of the unsubstituted samples of ungerminated and germinated products (7.37 %, respectively), although, protein values increased individually in substituted samples of both the ungerminated (10.39 % - 18.19 %) and germinated (10.83 % - 18.19 %) product samples but was more prominent in the germinated products. it can also be observed that the protein contents of the flour were higher than those observed from the products. Thus, it can be said that the flour samples of both the ungerminated and germinated samples highly portrayed the protein nature of soya beans present in the flours, it may also be assumed that the low protein values of the products may be as a result of heat effect of protein denaturation, as there was no protein enhancing ingredient (Egg, Margerine), used in the product formulation. Nwachukwu *et al*. [27] obtained lower values of protein from the production of noodles fortified with Soybean flour and Carrot powder. The protein values obtained in the work is comparable to the protein obtainable in an average western diet as reported by Bender [28].

In the ungerminated samples, Fiber content of the products decreased from 11.22 % in sample A to 2.38 % in sample E, with increase in substitution with soya bean flour. The same trend was also observed in germinated blend (10.96 % - 5.84 %). The decrease in the fiber content of the germinated products may have resulted from germination treatment.

**Table 4. Bioavailable mineral of extruded breakfast meal (%)**

| Samples | Magnesium | Phosphorous | Potassium | Calcium | Iron | Zinc |
|---|---|---|---|---|---|---|
| **A** | $58.14^{e}\pm0.20$ | $59.38^{c}\pm0.69$ | $54.30^{f}\pm0.14$ | $60.48^{cd}\pm0.31$ | $45.54^{j}\pm0.21$ | $23.92^{f}\pm0.00$ |
| **B** | $58.32^{e}\pm0.01$ | $56.60^{e}\pm0.71$ | $50.94^{g}\pm0.06$ | $55.91^{e}\pm1.24$ | $45.89^{i}\pm0.02$ | $22.18^{j}\pm0.01$ |
| **C** | $59.30^{e}\pm0.03$ | $49.85^{f}\pm0.41$ | $49.65^{h}\pm0.51$ | $50.21^{f}\pm0.01$ | $49.71^{h}\pm0.10$ | $23.76^{g}\pm0.00$ |
| **D** | $62.84^{cd}\pm0.06$ | $38.44^{g}\pm0.64$ | $48.71^{i}\pm0.21$ | $50.12^{f}\pm0.09$ | $52.95^{g}\pm0.04$ | $23.60^{h}\pm0.01$ |
| **E** | $68.01^{b}\pm0.00$ | $35.52^{h}\pm0.20$ | $47.32^{j}\pm0.48$ | $48.94^{g}\pm0.54$ | $53.99^{f}\pm0.01$ | $23.38^{i}\pm0.00$ |
| **F** | $61.42^{d}\pm2.05$ | $71.33^{a}\pm0.20$ | $71.78^{a}\pm0.27$ | $63.36^{a}\pm0.16$ | $54.68^{e}\pm0.00$ | $31.27^{a}\pm0.07$ |
| **G** | $61.98^{d}\pm0.01$ | $69.84^{b}\pm1.20$ | $60.29^{b}\pm0.11$ | $62.25^{b}\pm0.00$ | $58.13^{d}\pm0.00$ | $29.51^{b}\pm0.06$ |
| **H** | $62.61^{cd}\pm0.01$ | $60.65^{c}\pm0.64$ | $57.51^{c}\pm0.00$ | $61.45^{bc}\pm0.14$ | $61.13^{c}\pm0.04$ | $25.35^{c}\pm0.03$ |
| **I** | $64.01^{c}\pm0.00$ | $58.02^{d}\pm0.04$ | $56.86^{d}\pm0.16$ | $60.66^{cd}\pm0.00$ | $64.35^{b}\pm0.20$ | $24.73^{e}\pm0.00$ |
| **J** | $72.59^{a}\pm0.13$ | $55.77^{e}\pm0.41$ | $55.83^{e}\pm0.20$ | $59.76^{d}\pm0.00$ | $66.30^{a}\pm0.25$ | $24.81^{d}\pm0.01$ |

*Mean values are of duplicate determinations. Values within a column with the same superscript are not significantly different (p>0.05*

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF B- (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C - (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D - (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E - (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSSF F - (100:0) Germinated Sorghum Flour*
*GSSF G- (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H - (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I - (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

**Table 5. Sensory properties of extruded breakfast snacks**

| Samples | Colour | Taste | Texture | Overall Acceptability |
|---|---|---|---|---|
| A | $4.35^{a}\pm0.81$ | $4.10^{a}\pm0.79$ | $4.00^{a}\pm1.21$ | $4.15^{a}\pm0.73$ |
| B | $4.00^{a}\pm0.92$ | $4.05^{a}\pm0.83$ | $3.70^{ab}\pm1.03$ | $3.93^{a}\pm0.71$ |
| C | $3.80^{a}\pm1.11$ | $3.75^{ab}\pm1.07$ | $3.85^{ab}\pm1.27$ | $3.79^{ab}\pm0.91$ |
| D | $3.90^{a}\pm1.12$ | $3.15^{b}\pm1.14$ | $3.15^{b}\pm1.23$ | $3.37^{b}\pm0.91$ |
| E | $3.75^{a}\pm0.97$ | $3.50^{ab}\pm1.05$ | $3.60^{ab}\pm1.19$ | $3.60^{ab}\pm0.78$ |
| F | $4.05^{a}\pm0.89$ | $3.55^{ab}\pm1.05$ | $3.75^{ab}\pm1.11$ | $3.79^{ab}\pm0.81$ |
| G | $4.20^{a}\pm0.89$ | $3.70^{ab}\pm1.13$ | $4.20^{a}\pm0.83$ | $4.07^{a}\pm0.61$ |
| H | $4.05^{a}\pm1.10$ | $3.65^{ab}\pm1.23$ | $3.95^{a}\pm0.94$ | $3.89^{ab}\pm0.97$ |
| I | $4.00^{a}\pm0.97$ | $3.70^{ab}\pm1.03$ | $4.35^{a}\pm0.87$ | $4.02^{a}\pm0.69$ |
| J | $3.70^{a}\pm1.56$ | $3.40^{ab}\pm1.35$ | $4.35^{a}\pm0.99$ | $3.82^{ab}\pm0.81$ |

*Mean values are of duplicate determinations. Values within a column with the same superscript are not significantly different (p>0.05*

*Key:*
*USF A (Control) – (100:00) Ungerminated Sorghum Flour*
*USSF B - (90:10) Ungerminated Sorghum / Soya Beans Flour*
*USSF C - (80:20) Ungerminated Sorghum / Soya Beans Flour*
*USSF D - (70:30) Ungerminated Sorghum / Soya Beans Flour*
*USSF E - (60:40) Ungerminated Sorghum / Soya Beans Flour*
*GSSF F - (100:0) Germinated Sorghum Flour*
*GSSF G - (90:10) Germinated Sorghum/Soya Beans Flour*
*GSSF H - (80:20) Germinated Sorghum/Soya Beans Flour*
*GSSF I - (70:30) Germinated Sorghum/Soya Beans Flour*
*GSSF J - (60:40) Germinated Sorghum/Soya Beans Flour*

Inyang and Zkari [29] obtained lower values for germinated and fermented millet used for production of instant fura, While Niyi [30] obtained a contrast result in the fortification of pearl millet with soya bean flour.Low fiber is undesirable as it could cause constipation and that such diets have been associated with diseases of the colon like piles, appendicitis and cancer [31].Carbohydrate, content decreased with increase in substitution of sorghum with soya bean flour in the ungerminated products and ragged from 68.19 % to 63.60 % and significantly differs from each other. This decrease in carbohydrate content may have resulted from the presence of soya bean. A significant difference was also detected in the decreasing carbohydrate content (68.84 %-59.20 %) of the germinated products. Inyang and Zakara [29] reported similar trend, and inferred that this may have resulted from the work of alpha-amylase in breaking down of carbohydrates to simpler and more absorbable sugar by alpha-amylase which are utilized by the growing seedlings during the early stages of germination.

## 4.2 Total Minerals of Extruded Breakfast Meal

The total mineral of the breakfast meal for both the germinated and ungerminated samples are presented in Table 1. Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerves [31]. All products samples recorded increase in magnesium with increase in inclusion of soyabean flour. Ungerminated samples ranged from 68.58 mg/100g to 73.68 mg/100g while higher values ware obtained in the germinated products and ranged from 70.01 mg/100g to 80.68 mg/100g, this observed increase may be attributed to the soyabean inclusion. Similar trend was also observed in the work of Niyi *et al.* [30], as addition of soyabean flour to pearl millet improved the magnesium content from 10.50 mg/100g to 47.33 mg/100g. Although these values appear lower than the US RDA recommendation for the magnesium which is 350mg for men and 280mg for women. All samples analysed showed a decrease in phosphorous value and significantly differ ($p<0.05$) from each other with soyabean substitution, although the values obtained in the germinated (11.01 mg/100g to 15.28 mg/100g) samples were higher than those of the ungerminated samples (7.32 mg/100g to 11.48 mg/100g). This could be attributed to the germination treatment employed. Inyang and Zakari [29] buttressed the fact that germination improved the phosphorous content of fura powder than the untreated fura powder.

Substitution of sorghum with soyabean flour decreased the calcium contents of the ungerminated products from 91.46 mg/100g to 71.72 mg/100g. The same trend was observed in the germinated products with a decrease from 107.67 mg/100g to 93.71 mg/100g. The result of the present work is in contrast with the findings of Agbaja *et al*., [33] on the use of malted red sorghum and deffated soybean for production of complementary foods. Although soyabean inclusion caused a decrease, values from products with germinated sorghum were all higher than those of ungerminated sorghum. Calcium has been found to help in bone formation, and muscles and skeletal development [34]. The U.K. Department of Health recommended reference nutrients intake of 1000 mg/day of calcium for adult and 550 mg/day for infants and children [35]. Hence, the ungerminated products will supply 9.15 % to 7.17 %, and 16.63 % to 13.04 % of this mineral to adults and children respectively while the germinated blends will supply 10.77 % to 9.37 % and 19.58 % to 17.04 % of this mineral to adults and children, respectively. Potassium is an essential nutrient and has an important role in the synthesis of amino acid and protein in man [36]. Its content decreased from 847.52 mg/100g to 310.92 mg/100g for ungerminated products and from 913.56 mg/100g to 752.27 mg/100g for germinated products, with soyabean inclusion. Niyi [30], also observed a decrease in value (from 51.5 mg/100g to 41.96 mg/100g) on addition of soyabean flour to pearl millet flour. The value of germinated samples obtained from the present study is similar to those obtained from a blend of fermented maize, soya beans and carrot flour in the work of Barbar *et al.,* (2017). The germinated samples had highest values of potassium and it’s the most abundant mineral in all the products. Lower values (107.0-238.0 mg/100g) were recorded from breakfast cereals made from sorghum and pigeon pea [16].

Iron analysis revealed that the more soya bean content, the more Iron mineral increases in all samples in both ungerminated (41.72 mg/100g to 68.84 mg/100g) and germinated (58.52 mg/100g to 98.95 mg/100g) samples. Soya bean can be seen as a good source of iron as Adeoye *et al.* [37] also reported increase in iron content with addition of soya bean to cassava and rice flour in preparation of protein–enriched meal. Also, values obtained in the germinated products were higher than those of ungerminated products. Iron-deficiency anemia is a disease which arises due to the lack of iron especially for women and children in developing nations. Symptoms of iron deficiency take years to develop and include fatigue, weakness, and shortness of breath [38]. As an essential trace element, Iron is aids in cognitive development, oxidation of carbohydrate and responsible for haemoglobin formation, hence, it is highly required in adolescents especially at their period of rapid growth. All samples met the required USRDA for iron (8mg/day). Zinc content decreased from 5.10 mg/100g to 4.02 mg/100g for the ungerminated products whereas the germinated products ranged from 6.33 to 5.20mg/1000g. Substitution with soya beans did not improve the Zinc content of the samples although germination treatment of sorghum improved the values obtained in the breakfast meal of germinated samples. The values obtained from the samples and were lower than the US RDA of 12 - 15 mg/100g. Zinc plays a role in assisting enzyme reactions to blood clotting, and is essential to taste, vision, and wound healing.

### 4.3 Bioavailability of Extruded Breakfast Meal

According to Akusu *et al*. [17], bioavailability of a mineral is a portion of the mineral available for utilization in the body for the normal body functions and storage. It can be observed that for all minerals analysed, comparing individual samples of germinated and ungerminated products, the germinated samples had higher values of bioavailability than the corresponding ungerminated products, for all elements. This shows that germination treatment enhanced the mineral contents of the products made with germinated sorghum flour. The results for the mineral bioavailability are presented in Table 2. Substitution with soya beans flour improved the extractability of Magnesium and in turn bioavailability of Magnesium from 58.14 % to 68.01 % in the ungerminated samples. Values obtained in the germinated samples were higher and increased from 61.42 % to 72.59 %. Germination has been found to decrease the level of anti-nutrients present in cereals and maximize the levels of utilizable nutrients [28]. Among all samples, the phosphorous bioavailability of sample F (germinated sorghum flour) valued higher (71.33 %) than others and significantly differ from other samples. This May have resulted from its high extractability and also Tizazu *et al*. [39] reported that during germination, the total phosphorous (TP) and non-phytate phosphorous (NPP) contents of the sorghum flour increased significantly while phytate phosphorus (PP) content was decreased by the same amount that non-phytate phosphorous increased. The bioavailability of Potassium and Calcium, in the ungerminated products for all samples, decreased with increase substitution with soyabeans and are as follows; 54.30 % to 47.32 % and 60.48 % to 48.94 %, respectively, while the germinated products have values of 71.78 % to 55.83 %for potassium and 63.36 % to 59.76 %. Germination resulted to increase in the values. These results are in accordance with the work of Tizazu *et al.,* [39]. This shows that these aforementioned minerals in the germinated samples will be highly available for the body than in the ungerminated blends.

Anti-nutritional factors chelate metals such as iron and zinc and reduce the absorption of these nutrients. Bioavailability of Iron increased with substitution of sorghum with soyabean and was higher in the germinated products. Luo *et al.* [40] reported an increase in Iron bioavailability as a result of germination of soya beans. Zinc element showed higher bioavailability in the germinated products (31.27 % to 24.81 %) than in the ungerminated products (23.92 % to 23.38 %).According to Gashaw *et al*. [41], the presence of anti-nutritional factors affects the bioavailability of minerals**.** Generally, all elements showed high bioavailability in the germinated products, this may be attributed to their high extractability and low antinutrient content.

### 4.4 Sensory Properties of Extruded Breakfast Meal

The mean scores for the sensory analysis are presented in Table 3. From the results, the colour, texture, taste, and overall acceptability all compared favourably with the control sample. The scores for the colour ranged from 3.75 to 4.35 and 3.70 to 4.05 for ungerminated and germinated samples respectively. According to Alobo (2001), efficient heat transfer helps to prevent colour darkening caused by maillard reaction and caramelization. This could be a reason for colour recorded in the breakfast meal. There was no significant difference among the samples analysed for colour. For the taste, both the germinated and ungerminated samples compared favourably with the control recording the highest mean score. Taste is a code given to different food by the sensorial palate when the food is ingested into the mouth. The texture of the samples recorded higher scores with the germinated samples, this could be as a result of germination. The overall acceptability shows that sample A has the highest preference for the ungerminated products while sample G and I with 10 %and 30 % soyabean inclusion respectively, has the highest preference for the germinated samples. Overall, sample A ranked highest mean score among the products for all parameters analyzed but did not differ significantly from the sample G and I.

## 5. CONCLUSION

In a bit to improve the nutritional status of local staples, novel processing methods are being introduced into food processing. This work has shown that there is improvement in the nutrient composition and mineral element in the germinated product blends of sorghum and soya beans. Germinated product offers higher protein, ash, and Fat content with increase in the total mineral (magnesium, phosphorous, potassium calcium, iron, and zinc) with potassium as the most abundant mineral. Some of the calculated minerals measured more than 20 % of the recommended RDA, particularly Magnesium and Zinc which recorded 28.81 % and 52.75 %, respectively. Some of the parameters analyze in both ungerminated and germinated blends compared favorably with each other.For sensory evaluation, control sample recorded the highest mean score of overall acceptability as regards to the taste while sample I and J had a higher mean score for Texture. Consumption of breakfast meal will also contribute significantly to the RDA for both children and adult especially for magnesium, calcium, potassium, iron and zinc on a daily basis. Composite blends as was used in the present study could serve as an alternative source of less expensive yet nutritious flours for the production of breakfast meal and other confectionaries. Hence production of breakfast meal with germinated sorghum and soya beans inclusion up to (60:40) should be encourage because of its high nutrient content.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. O'Neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, Berk M, Jacka FN. Relationship between diet and mental health in children and adolescents: a systematic review. Am J Public Health. 2014;104(10):e31-42.
   DOI: 10.2105/AJPH.2014.302110. PMID: 25208008; PMCID: PMC4167107.
2. Matthys C. et al. Breakfast habits affect overall nutrient profiles in adolescents. Public Health Nutrition. Public Health Nutr. 2007;10(4):413-21.
3. Tortoe C, Akonor PT, Buckman ES. Potential uses of sweet potato-wheat composite flour in the pastry industry based on proximate composition, physicochemical, functional and sensory properties of four pastry products. J. Food Process Preserve; 2017.
4. Akonor PT, Tortoe C, Buckman ES, Hagan L. Proximate composition and sensory evaluation of root and tuber composite flour noodles. Cogent Food Agric. 2017;3:1-7.
5. Chauhan A, Saxena DC, Singh S. Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. Cogent Food Agric. 2016;2(1):1125773.
6. Ho LH, Abdul Latif NWB. Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (Hylocereusundatus) peel flour blends. Cogent Food Agric. 2016;2(1):1136369.
7. Kidane G, Abegaz K, Malugeta A, Singh P. Nutritional analysis of vitamin A enriched bread from orange flesh sweetpotato and locally available wheat flours at Samre Woreda, Northern Ethiopia. Curr Res. Nutr. Food Sci. 2013;1(1):49-57.
8. Amagloh FK, Weber JL, Brough L, Hardacrel A, Mutukumiral AN, Coad J. Complementary food blends and malnutrition among infants in Ghana: A review and a proposed solution. Sci. Res. Essays. 2012;7(9):972-988.
9. Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG. Predictors of growth from 1 to 18 months among breast-fed Ghanaian infants. Eur. J. Clin. Nutr. 2000;54:41-49.
10. Pobee RA, Johnson PNT, Akonor PT, Buckman ES. Nutritional, pasting and sensory properties of a weaning food from rice (Oryza sativa), soybeans (Glycine max) and kent mango (Mangiferaindica) flour blends. Afr. J. Food Agric. Nutr. Dev. 2017;17(1):1111533-11551.

11. Adelekan AO, Oyewole OB. Production of *ogi* from germinated sorghum supplemented with soybeans. African Journal of Biotechnology. 2010; 9(42):7114-7121.
12. Wang YD, Fields ML. Germination of corn and sorghum in the home to improve nutritive value. Journal Food Sci. 1973;43:1113-1115.
13. Akinrele IA, Edwards CA. An assessment of the nutritive value of maize-soya mixture, soy-ogi as a weaning food in Nigeria. Br. J. Nutr. 1971;26:177-185.
14. Salunkhe DF, Kadam SS. CRC handbook of legumes, nutritional chemistry, processing, technology and utilization; 1989.
15. Cowan JC, Rackis J, Wolf WJ. Soyebeans protein flavor components: A review. Journal of Oil Chem. Soc. 1973;50:426.
16. Mbaeyi IE. Production and evaluation of breakfast cereal using pigeon-pea (Cajanuscajan) and sorghum (Sorghum bicolor L.). An M.Sc. Thesis, Department of Food Science and Technology, University of Nigeria, Nsukka; 2005.
17. Akusu OM, Kiin-Kabari DB, Isah EM. Anti-nutrients, bioaccessibility and mineral balance of cookies produced from processed sesame seed flour blends. International Journal of Food Science and Nutrition Engineering. 2019;10(1): 1-11.
18. AOAC. Official method of Analysis, 20th Ed. Association of analytical chemists, Washington D.C, USA; 2012.
19. AOAC. Official methods of analysis of the AOAC (18th ed.). Washington, DC: Author; 2000.
20. Chauhan BM, Mahjan H. Effect of natural fermentation on extractability of minerals from pearl millet flour. Journal of food science. 1988;53:1576-1577.
21. Giami SY, Barber LI. Utilization of protein concentrates from ungerminated and germinated fluted pumpkin (Telfairia occidentalis Hook) seeds in cookie formulations. Journal of the Science of Food and Agriculture. 2004;84(14):1901 - 1907
22. Eke-Ejiofor J, Williams I. Evaluation of Defatted soybean flour Inclusion on the properties of Rice based Biscuits Department of Food Science and Technology, Rivers State University of Science and technology International Journal of Biotechnology and Food Science. 2016;4(4):63-71, ISSN: 2384-7344.
23. Okonkwo JC, Umegwuagu JL, Okonkwo IF, Onukwo DN. Effect of sun dried, dehulled and boiled kidney beans on hematological and serum biochemistry of broiler birds. Int. J. Environ. Agric. Biotech. 2019;4:735-740.
24. Sanni OL, Adebowale AA, Filani TA, Oyewole OB, Westby A. Quality of flash and rotary dried fufu flour. Journal of Food Agric Environ. 2006;4:74-78.
25. Adegunwa MO, Bakare HA, Akinola OF. Enrichment of Noodles with Soy Flour and Carrot Powder. Journal of Nigerian Institute of Food Science and Technology. 2012;30(1):74 – 81.
26. Zegeye S, Hadero T, Hassen Y. Effect of blending ratio of soybean and sorghum flour on the proximate composition and sensory quality of cookies produced from Soft Wheat. Journal of Food Process Technology. 2019;10:787.
27. Nwachukwu CN, Onyemechara EJ, Ukwujiagu CU. International Journal of Innovative Food, Nutrition & Sustainable Agriculture. 2020;8(3):62-75.
28. Bender DA. Protein-energy ratio: A Dictionary of food and nutrition. Encyclopedia.com; 2005.
Retrieved on the 19 Apr. 2009 from Available: http://www.encyclopedia.com.
29. Inyang CU, Zakari UM. Effect of germination and fermentation of pearl millet on proximate, chemical and sensory properties of instant “fura”- a Nigerian cereal food. Pakistan Journal of Nutrition. 2008;7(1):9-12.
30. Oluwagbenla Henry Niyi. Nutritional Evaluation of Pearl Millet Fortified with Soyabeans flour. Chemistry Research Journal. 2020;5(4):143-151.
31. Okon BD. Studies on the chemical composition and nutritive values of the fruits of African star apple. M.Sc. Thesis, Universitry of Calabar; 1983.
32. Adeyeye, Emmanuel, Agesin OO. Dehulling the African Yam Bean ( Sphenostylis stenocarpa Hochst. ex A. Rich) Seeds : Any Nutritional Importance? Note I. Bangladesh Journal of Scientific and Industrial Research. 2007;42.
DOI: 10.3329/bjsir.v42i2.469.
33. Agbaje RB, Oloye DA, Olatunji CA, Olawale-Olakunle OE. Anti-nutrient and mineral properties of Complementry Food produced from Malted Red Sorgum and

Defatted Soybean Flour Blend. Arch Food Nutr Sci. 2017;1:033-038.

34. Miniello Vito, Moro, Guido L, Armenio. Prebiotics in infant milk formulas: New perspectives. Acta paediatrica (Oslo, Norway: 1992). Supplement. 2003;91:68-76.
DOI: 10.1080/08035320310018754.
35. Pravina Piste, Sayaji Didwagh, Avinash Mokashi. Calcium and its role in human body. International Journal of Research in Pharmaceutical and Biomedical Sciences. 2013;4(2):659-668.
36. Malik CP, Scivastava AK. Textbook of plant physiology Luchiana. 21 New chillies, Tropical Science. 1982;33:226-231.
37. Adeoye, Babatunde, Akinbode, Badiu A, ADESIDA & T, Akpa. Production and Evaluation of a Protein-Enriched Meal from Composite Flour of Cassava, Rice and Soybean. SDRP Journal of Food Science & Technology. 2020;5:18-26.
DOI:10.25177/JFST.5.1.RA.10594.
38. Ryan J, Kuppler B, Jian-Rong Li, Hong-Cai Z. Selective gas ametal-organic separation in metal-organic frameworks. Chemical Society Reviews. 2009;38(5):1477-1504.
39. Tizazu, Shimelis, Urga, Kelbessa, Belay, Abera C, Abuye Retta, Negussie. Effect of germination on mineral bioavailability of sorghum-based complementary foods. African Journal of Food, Agriculture, Nutrition and Development. 2011; 11.
DOI:10.4314/ajfand.v11i5.70438.
40. Luo, Yu-Wei & Xie, Wei-Hua & Jin, Xiao-Xiao & Wang, Qian & He, Yi-Jian. Effects of germination on iron, zinc, calcium, manganese, and copper availability from cereals and legumes. CyTA - Journal of Food. 2013;12:22-26.
DOI:10.1080/19476337.2013.782071.
41. Gashaw MT, Abebe H, Esayas K. Bioavailability of minerals in cookies developed from blend of moringa leaf powder and wheat flour for iron deficient lactating mothers. *International Journal of Food Science and Nutrition Engineering*. 2015;5(6):226-232.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sdiarticle4.com/review-history/70406*