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PRODUCTION AND QUALITY EVALUATION OF SNACKS FROM BLENDS OF GROUNDNUT CAKE AND PIGEON PEA FLOUR

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ABSTRACT

This study evaluated the nutritional characteristics of snacks produced from blends of groundnut cake and pigeon pea flour. Wholesome groundnut seeds and pigeon pea seeds were purchased and processed into cake and flour respectively. Five blends of groundnut cake and pigeon pea flour were formulated and designated with codes as follows: 90% groundnut cake: 10% pigeon pea flour (202), 80% groundnut cake: 20% pigeon pea flour (303), 70% groundnut cake: 30% pigeon pea flour (404), 60% groundnut cake: 40% pigeon pea flour (505), 50% groundnut cake: 50% pigeon pea flour (606) and 100% groundnut cake (101) which served as the control and the functional properties were analyzed. Snacks were produced from the blends and the proximate, mineral and sensory characteristics were evaluated. The functional properties results ranged from 0.68 g/ml to 0.88g/ml for bulk density, 1.81g/g to 2.51g/g for water absorption capacity, 0.80g/g to 0.95g/g for oil absorption capacity, 21.48% to 27.25% for foam capacity, 77.31% to 91.32% for foam stability, 38.53 to 50.22 for swelling index. Proximate composition and energy value of the flakes indicated significant ($p<0.05$) differences. Mineral composition of the samples showed significant ($p<0.05$) differences in calcium, magnesium, phosphorus, potassium, iron and zinc with values ranging from 90.15 mg/100g to 114.72 mg/100g), 143.11 mg/100g to 151.86mg/100g, 304.65 mg/100g to 337.03mg/100g, 113.46 mg/100g to 133.81 mg/100g, 4.11 mg/100g to 5.03mg/100g and 2.21 mg/100g to 2.82mg/100g respectively. Sensory acceptability results showed that the sample with 80% groundnut cake and 20% pigeon pea flour (303) was the most preferred among the test samples. This has revealed the potential of production of nutrient-rich snacks from blends of groundnut cake and pigeon pea flour thereby creating varieties and increased application of pigeon pea.

Keywords: Snacks, nutrient-rich, groundnut cake, pigeon pea flour, blends

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INTRODUCTION

In today's society, consumption of snacks among all age groups is common due to its convenience. Snacking contributes close to one- third of daily energy intake, with many snacks being energy-dense but nutrient poor foods (Njike *et al*., 2016). Snacks are convenient foods consumed between regular meals, which range from fruit, vegetables and whole grains (Lucan *et al*., 2010). Protein-rich snacks are produced from foods high in protein. Some of the protein plant-based food material used can be legumes, nuts such as peanut, walnut, cashew nut, almond and so on (Olabinjo and Olumuorewa, 2020). Groundnut (*Arachis hypogea*) also known as peanut belonging to the Fabacea family, is the second most important cultivated food legume and the fourth largest oilseed crop in the world (Shilman *et al*., 2011). It is also rich in vitamin E, K and B (the richest source of thiamine and niacin) (Gulluoglu *et al*., 2016). Groundnut can be boiled, toasted, processed into oil, groundnut cake, peanut butter which can be consumed directly or used to produce other foods. Groundnut cake (*kuli-kuli*) is the by-product of oil extraction from groundnut. It is also used as a groundnut-based snack by the natives of West Africa (Achimugu and Okolo, 2020). Groundnut cake (*Kuli-kuli*) just like its parent material groundnut is rich in protein and crude fat (Kolapo *et al*., 2012). It is categorized as a street food, by being cheap, accessible and meets the basic needs of the urban population (Boli *et al*., 2014).

Pigeon pea (*Cajanus cajan*) is from the family of *Fabacea*, It is the sixth most important legume crop in the world. This legume is grown all over the tropics and subtropics for human consumption (FAO, 2016). Pigeon pea is an important source of income for rural households (Dansi *et al*., 2012). Saxena *et al*. (2010) reported that pigeon pea seeds are highly nutritious. The mature seeds contain 18.8% protein, 53% starch, 2.3% fat, 6.6% crude fiber and 250.3 mg/100g minerals. Pigeon pea is a good source of essential minerals such as magnesium, calcium, iron, potassium, sodium, manganese, chromium, and zinc. Pigeon peas stimulate growth, manage blood pressure, prevent anemia, and boost heart health. It also helps in weight loss, improves digestion, strengthens the immune system, increases energy and eliminates inflammation (Ogbonna *et al*., 2021). It can be cooked and consumed or processed into flour and used for production of variety of food products like snacks.

In Nigeria, the high cost of industrially produced protein rich products makes them out of reach to low income earners who consequently consume snacks made from cereals that have low nutritional value. There is therefore the need to develop very affordable food that is rich in protein. Also, there is an underutilization of pigeon pea due to its tough texture and long cooking time. The development of protein-rich snacks from inexpensive and locally available indigenous crops like groundnut and pigeon pea will improve the utilization of pigeon pea which is underexploited. The production of groundnut-pigeon pea snacks will add varieties to the already existing products thereby leading to the increase in the utilization of pigeon pea. The main objective of this study is to evaluate the functional properties of groundnut cake-pigeon pea composite flour, the nutrients and organoleptic attributes of the snacks.

MATERIALS AND METHODS

SOURCES OF RAW MATERIALS

Groundnut seed (*Arachis hypogea*) and pigeon pea seed (*Cajanus cajan*) used for this study were procured from Aba new market (Ahia Ohuru) in Aba South Local Government Area, Abia state. The processing was carried out at Food Science and Technology Laboratory, Michael Okpara University of Agriculture, Umudike. The analysis was carried out at National Root Crop Research Laboratory Umudike, Abia State.

Raw Material Preparation

Production of groundnut cake

Groundnut seeds were sorted, washed with portable water and drained. Thereafter, they were sundried for 2 hours and toasted with *garri* using a cast iron pan on a kerosene stove for 15 minutes. The toasted groundnut seeds were sieved, cooled and the seed coat removed and winnowed to obtain clean groundnut seeds which were milled using an attrition mill to obtain groundnut paste. The paste was then pressed to remove the oil and groundnut cake was obtained (Emelike and Akusu, 2018).

Production of pigeon pea flour

Pigeon pea flour was produced using the method as described by Akubor (2017) with slight modification. Pigeon pea seeds were sorted, washed and soaked in portable water for 12 hours. Thereafter, the seeds were drained and sun dried for 8 hours, after which they were toasted using a cast iron pan on a kerosene stove for 30 minu tes. It was cooled, broken using an attrition mill and winnowed to remove the seed coat after which they were milled using an attrition mill and sieved through 500 µm sieve to obtain pigeon pea flour.

Blending of Groundnut Cake and Pigeon Pea Flour

The groundnut cake and the pigeon pea flour were blended into different ratios as presented in Table 1.

Production of the Snacks

The snacks were produced according to Tay *et al*. (2021). The groundnut cake and pigeon pea flour blends (Table 1) were dissolved and thoroughly mixed with water and salt in a bowl to form a batter. The batter was poured and rolled on a baking pan and baked using a manual oven for 1h 30 min. The baked snacks were manually broken into small flakes, cooled and packaged in an airtight nylon and stored.

Determination of Functional Properties

Bulk Density: A 10ml capacity graduated measuring cylinder was weighed and sample was gently filled into the cylinder. The bottom of the cylinder was gently tapped on the laboratory bench severally until there was no diminution of the sample level after filling to the 10ml mark. Bulk density (g/ml) was then calculated as weight of sample (g) / volume (ml) according to Onwuka (2018).

Water Absorption Capacity (WAC): Water absorption capacity was determined as described by Onwuka (2018). One (1g) of sample was weighed and placed into a conical graduated centrifuge tube. A waring whirl mixer was used to mix the sample thoroughly, 10ml was added and sample was allowed to stay for 30min at room temperature and then centrifuged at 5000 × g for 30min. The volume of the free water (supernatant) was read using 10ml measuring cylinder. Water absorption was calculated as the amount of water absorbed (total minus free water) x 1 g/ml.

Oil Absorption Capacity (OAC): The method as described by Onwuka (2018) was adopted for the determination of OAC. Refined groundnut oil with density of 0.92g/ml was used. One gram (1g) of the sample was mixed with 10ml of the oil (V_1), for 30s. The sample was allowed to stand for 30min at room temperature and then centrifuged (Centurion scientific, Model k241) at

10,000rpm for 30min. The amount of oil separated as supernatant (V_2) was measured using 10ml cylinder. The difference in volume was taken as the oil absorbed by the samples. The result obtained was calculated using the following equation:

Oil absorption capacity = $\frac{(V_1 - V_2)P}{\text{Weight of sample}}$

Where, V_1 = the initial volume of oil used

V_2 = the volume not absorbed

P = the density of oil (0.92g/ml)

Foam Capacity and Stability: The foam capacity and stability were determined by the method described by Onwuka (2018). A known weight of the flour sample was dispersed in 100ml distilled water. The resulting solution was homogenized for 5min at high speed. The volume remaining at interval of 0.00, 0.30, 1, 2, 3, 4 up to 24h was noted for the study of foaming stability. Foam capacity and stability was calculated using the formula;

$$\text{Foaming capacity (\%)}: \frac{\text{Volume after homogenizaton} - \text{Volume before homogenization}}{\text{Volume before homogenization}} \times \frac{100}{1}$$

$$\text{Foam stability (\%)}: \frac{\text{Foam volume after time (t)}}{\text{Initial foam volume}} \times \frac{100}{1}$$

Swelling Index: This is the ratio of the swollen volume to the original volume of a unit weight of the flour. The method reported by Onwuka (2018) was used. One (1) gram of the flour sample was weighed into a clean dry measuring cylinder. The height occupied by the sample was recorded (H_1) and then 5ml of distilled water added to the sample. This was left to stand undisturbed for 1h, after which the height was observed and recorded again (H_2). The swelling index was then calculated using the following equation: $SI = \frac{H_2}{H_1}$

Where: H_1 = initial height

H_2 = final height

Determination of Proximate Composition of the Snacks

Moisture content: Moisture content of the snacks was determined according to the method described by Onwuka (2018). Two millimeters of each of the samples were weighed into different moisture cans. They were then placed in an oven at 150˚C for 3h, drying was stopped after obtaining a constant value consecutively. The flakes were cooled in a desiccator and weighed. Moisture content of the flakes was then calculated as follows:

$$\text{Moisture}(\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where: W_1 = initial weight of empty can,

W_2 = weight of empty can + sample before drying,

W_3 = final weight of empty can + sample after drying.

Crude Protein content: Crude protein of the samples was determined using the Kjedahl method as described by Onwuka (2018). One millimeter of the sample was introduced into the digestion flask. Kjedahl catalyst (selenium tablets) was added to the sample. Twenty milliliters of concentrated sulphuric acid was added to the sample and fixed to the digester for 8h until a clear solution was obtained. The cooled digest was transferred into 100ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for 10m after boiling. Twenty milliliters of 4% Boric acid was pipetted into conical flask. Five drops of methyl red was added to the flask as indicator and the sample was diluted with 75ml distilled water. Ten milliliters of the digest was made alkaline with 20ml of sodium hydroxide (NaOH) (20%) and distilled. The steam exit of the distillatory was closed and the change of color of boric acid solution to green was timed. The mixture was distilled for 15min. The filtrate was then titrated against 0.1N Hydrochloric acid (HCl).

The total percentage of protein was calculated:

Protein(%) = % nitrogen x conversion factor (6.25).

Crude Fibre content: The crude fibre of the snack samples were determined according to the Onwuka (2018) method. Two millimeters of each of the snacks were boiled under reflux for 30min with 200ml of solution containing 1.25g of tetraxosulphate (vi) acid (H_2SO_4) per 100ml of solution. The solution was filtered through linen on a flaunted funnel and washed with water until the washing is no longer acidic. The residue was then transferred to a beaker and boiled for

30min with 100ml of solution. The final residue was filtered through a thin but closer pad of washed and ignited asbestos in a Gosh crucible. The residue was then dried in an electric oven and weighed. The residue was incinerated, cooled and weighed. Crude fibre content of the instant meal was then calculated as follows:

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1}$$

Where: W_1 = weight of sample used

W_2 = weight of crucible plus sample

W_3 = weight of sample crucible

Fat content: The fat content of the samples were determined using solvent extraction in a soxhlet apparatus as described by Onwuka (2018). Two millimeters of each of the samples were wrapped in a filter paper and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and to a weighed oil extraction flask full with 200ml of petroleum ether. The ether was brought to its boiling point, the vapour condensed into the reflux flask immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60˚C for 30min and then weighed.

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Ash content: The method described by Onwuka (2018) was used to determine the ash content of the snacks. Porcelain crucible were dried and cooled in desiccators before weighing. Two millimeters of the samples were weighed into the crucible and the weight taken. The crucible containing the samples were placed into the muffle furnace and ignited at 550^{o}C. This temperature was maintained for 3h. The muffle furnace was then allowed to cool; the crucibles were then brought out, cooled and weighed. The ash content was calculated as follows:

$$\text{Ash(\%)} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100$$

Where: W_2 = weight of crucible + ash,

W_1 = weight of empty crucible.

Carbohydrate content: Carbohydrate content of the snacks samples was determined by using the formula described by Onwuka (2018).

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

Determination of Energy value

The energy value was estimated using Atwater factors as described by Onwuka (2018). The energy value was calculated by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel value of 4, 9, and 4kcal/g respectively and taking the sum of their products.

The energy value was calculated thus:

F_e = (% CP x 4) + (% CF x 9) + (% CHO x 4)

Where: F_e = Food energy (in grain calories), CP= Crude protein

CF= Crude fat, CHO= Carbohydrate

Determination of Mineral Content of the Snacks

Calcium and magnesium: Calcium and magnesium content of the snacks samples were determined by the complexiometric titration method described by Onwuka (2018). Twenty milliliters of the samples extract was dispersed into conical flask and treated with pinches of the masking agents (Hydroxylamine hydrochloride, Sodium cyanide and Sodium ferrocyanide). The flask was shaken and the mixture dissolved. Twenty milliliters of ammonia buffer was added to it to raise the pH to 10.00. The mixture was titrated against 0.02N EDTA solution using Erichrome Black T as indicator. A reagent blank was also titrated and titration in each case was done from deep red to a permanent blue end point. The titration value represents both Ca^{2+} and Mg^{2+} in the test sample. The analysis was repeated to determine Ca^{2+} alone in the test samples. Titration of calcium alone was done in similarity with the above titration, 10% NaOH was used in place of ammonia buffer and solechrome dark blue indicator in place of Erichrome black T.

Total calcium and magnesium content were calculated separately using the following formula:

$$\text{Ca/Mg (mg/mg)} = \frac{100}{W} \text{x} \frac{T - B\ (N \text{ x Ca/Mg})}{Va} \text{x} \frac{Vf}{1}$$

Where W=Weight of sample, T = Titre value of sample, B = Titre value of blank

Ca = Calcium equivalence, Mg =Magnesium equivalence

Va = Volume of extract titrated, Vf = Total volume of extract

N=Normality of titrant (0.02N EDTA).

Phosphorus: Phosphorus content of the samples was determined according to the method described by Onwuka (2018) by using hydroquinone as a reducing agent. Five milliliters (5ml) of the test solution was pipetted into 50ml graduated flask. Then 10ml of molybdate mixture was added and diluted to mark with water. It was then allowed to stand for 30m for colour development. The absorbance was measured at 600nm against a blank. A curve relating absorbance to mg phosphorus present was plotted. Using the phosphorus standard solution, and following the same procedure for the sample, a standard curve was plotted to determine the concentration of phosphorus in the sample.

$$\text{Phosphorus (\%)} = \frac{\text{graph reading x solution volume}}{100}$$

Potassium: Potassium was determined by the procedure described by Onwuka (2018). Potassium standard was prepared. The standard solution was used to calibrate the instrument read out. The meter reading was at 100% E (emission) to aspire the top concentration of the standards. The percent emissions of all the intermediate standard curves were plotted on linear graph paper with these readings. The snacks sample solution was aspired on the instrument and the readings (% emission) were recorded. The concentration of the element in the sample solution was read from the standard curve and potassium calculated as follows:

$$\text{Potassium (\%)} = \frac{\text{ppm X 100X DF}}{1000}$$

Where: Df = Dilution factor, ppm = part per million

Iron: The iron content of the sample was determined by spectrophotometric method of AOAC (2010). Five millimeters of the samples was first digested with 20ml of acids mixture (650ml concentrated HNO_3, 80ml perchlonic acid and 20ml concentrated H_2SO_4). The digest was diluted by making up to 100ml with water. Two milliliters (2ml) of the flakes solution was pipetted inside a flask before 3ml buffer solution, 2ml hydroquine solution and 2ml bipyridyl solution were added. The absorbance reading was taken at wavelength of 520nm and the blank was used to zero the instrument. Also, a standard solution of iron was prepared by dissolving 3.512g of Fe $(NH_4)_2.(SO_4)$. $6H_2O$ in water and two drop of 0.5N HCL was added and diluted to 500ml with distilled water. The iron standard was further prepared at different concentration at 2ppm to 10ppm by diluting with distilled water. Three milliliters (3ml) of buffer solution, 2ml of hydroquinone solution and 2 ml of bipyridtyl solution was added. Absorbance reading was taken at 520nm. The readings were used to plot a standard iron curve for extrapolation.

Zinc: Zinc was determined by the method described by Onwuka (2018). One gram of each of the samples was first digested with 20ml of acid mixture (650ml concentrated HNO_3, 80ml perchloric acid (PCA). Five milliliters of the digest was collected and diluted to 100ml with H_2O. This now served as sample solution for AAS reading. Also a standard solution of respective elements concentration of 0.0 to 1.0 was taken. The readings were used to plot a standard zinc curve for extrapolation and zinc was calculated as follows:

$$Zn = \frac{Vf}{Vs} \times \frac{1}{10} \times \frac{100}{W} \times Df$$

W= Weight of sample analyzed, Vf = Volume of extract

Vs = Volume of extract used, Df = Dilution factor

Evaluation of Sensory Properties of the Snacks

The sensory attributes of the snacks were evaluated using the method described by Iwe (2014). Twenty (20) panelists randomly selected from students of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, evaluated the appearance, taste, aroma, texture and general acceptability of the snacks. The semi-trained panelists were instructed on how to evaluate the sensory attributes of the snacks prior to the exercise. Quality attributes of the snacks were scored in a 9-point Hedonic scale. The degree of likeness was expressed as follows: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), dislike extremely (1).

Experimental Design

Completely Randomized Design (CRD) was used for this study.

Statistical Analysis

One-way analysis of variance (ANOVA) was carried out on the data generated in this research using the SPSS version 23.0 software. The analyzed data were expressed as mean ± SD (standard deviation). The Duncan Multiple Range Test (DMRT) method was used to compare the means of experimental data at 95 % confidence interval.

RESULTS AND DISCUSSION

Functional Properties of Groundnut Cake and Pigeon Pea Flour Blends

Table (2) shows the functional properties of groundnut cake and pigeon pea flour blends. The highest BD (0.88g/ml) was recorded in sample 606 (GC50%: PPF50%), while sample 101 (GC100%) had the lowest BD (0.68g/ml) and there were significant ($p<0.05$) differences among the samples. The bulk density obtained in this study was higher than the values (0.592 g/cm^3 to 0.647g/cm^3) for pigeon pea flour (Arukwe *et al*., 2017). Bulk density is very vital in determining packaging requirement and material handling (Offia-Olua, 2014). The high bulk density of the flours suggests their suitability for application and use in food preparations. The water absorption capacity (WAC) which ranged from (1.81g/g to 2.51 g/g) differed significantly ($p<0.05$) among the samples. The least WAC (1.81g/g) was observed in sample 606, while sample 101 recorded the highest value (2.51g/g). The WAC of a food product measures the water holding ability by the starch after the swelling in excess water, which corresponds to weight of the gel formed, and therefore is an index of degree of starch gelatinization (Awuchi, 2019). Water absorption capacity is considered a critical function of protein in viscous foods, like soups, gravies, dough and baked products. It is important in foods as it relates to other functional properties such as emulsification, solubility, adhesion, dispersibility, wettability, cohesion, viscosity and gelation (Maha *et al*., 2011).

The oil absorption capacity (OAC) ranged from (0.80 to 0.95g/g) with the highest value The OAC values were significantly ($p<0.05$) different from each other. OAC is mainly attributed to the entrapment of oils physically. It is an indication of the rate at which protein bind to fat in food formulations (Oppong *et al*., 2015). Ingredients with high oil absorption capacity play important role in stabilizing food systems with high fat content and can also act as emulsifiers (Akubor, 2017b). It makes flour to have functional uses in the production of foods like sausage.

Oil absorption capacity is important for nutrient and energy density of food products especially for infant and young children. In addition, the high oil absorption capacity also makes the flour suitable in facilitating enhancement in mouth feel and flavor when used in food preparation (Berul, 2015).

The foam capacity (FC) of the flour blends ranged from 21.48% to 27.25%. The least (21.48%) and highest (27.25%) values of FC were observed in samples 101 and 606 respectively. The values were significantly ($p<0.05$) different from each other. The increase in pigeon pea flour improved the FC of the flour blends. Foam capacity is the extent to which protein disperses in water to form foam (Arukwe *et al.*, 2021). This implies that legumes may form higher foam since they are rich in protein. Foam capacity is used to improve consistency and appearance of foods (Akubor and Badifu, 2014). However, food ingredients with low foaming capacity are suitably applied in biscuits, crackers, and cookies (Borja *et al.*, 2013).

The foam stability (FS) of the flour blends ranged from 77.31% to 91.32% showing significant ($p<0.05$) difference among the flour samples. The highest FS (91.32%) was recorded in sample 101 while the lowest (77.31%) was recorded in sample 606. Increase in pigeon pea flour resulted to decrease of the FS. Good foam stability are desirable qualities for flours used for the production of various baked products such as cakes, sponges, ice creams, marshmallows, whipped creams, and bread require food ingredients with high foaming capacity (Atuonwu and Akobundu, 2010). The FS obtained in this study for the composite flours are quite high which implied that the flour blends may be useful as aerating agents in food productions (Hung *et al.*, 2004).

The swelling index (SI) of the flour blends ranged from 38.53% to 50.22%. The highest SI (50.22%) was recorded in sample 606, while sample 101 had the least value and they were significantly ($p<0.05$) different from each other. The swelling index of flours is influenced by the particle size, species variety and method of processing or unit operations (Suresh and Samsher, 2013). The extent of the swelling index depends on the availability of water, temperature, type of starch and other carbohydrate as well as proteins. The high swelling index observed in the study suggests that the flour blends could be useful in food system where swelling is required.

Swelling index provide suitable predictive method for identifying noodle-quality flours (Awuchi, 2019).

Proximate Composition and Energy Value of Snacks from Groundnut Cake and Pigeon Pea Flour

Table (3) shows the proximate composition and energy value of groundnut-pigeon pea snacks. The moisture content (2.85% to 4.18%) was generally low and was significantly ($p<0.05$) different. The low moisture in the sample could be attributed to the baking process which has the capacity to extract almost all available free moisture. The results of moisture content were within the safe moisture level (≤10%) for long term storage of flour (Akinoso *et al.*, 2016). Arukwe (2021) reported that low moisture content is advantageous for storage stability and enhanced shelf life of products. Hence, the snacks might remain stable for a long period without spoilage at ambient temperature.

Protein content of the samples ranged from 17.45% to 28.81%. Samples 101 and 606 respectively recorded the highest (28.18%) and lowest (17.45%) values which were significantly ($p<0.05$) different. The result obtained is less than 27.83% to 46.18 % reported by Solomon and Judith (2020) for melon-groundnut kuli-kuli. The values were higher than (7%-8%) minimum recommended for prevention of PEM (Protein-energy malnutrition) by FAO/WHO/UNU (1985). The high protein content indicates that the snacks might be valuable in combating protein-energy malnutrition.

Crude fibre contents of the samples ranged from 2.61% to 3.77% and were significantly ($p<0.05$) different from one another. The crude fibre content of the control sample was lower than the composite samples, reflecting the beneficial effect of complementation. The crude fibre content increased with the inclusion of pigeon pea flour. This implies that pigeon pea is a good source of fibre because the value obtained for fiber content is within the range (>3g dietary fiber/ 100g food) recommended by Nutritional Claims for Dietary Fibre Foods (Official Journal of European Commission, 2012). The result obtained in this study is in agreement with the report of Arukwe (2021) on the increased fibre content due to supplementation of combined processed pigeon pea flour with wheat flour. Crude fibre is a measure of the quantity of indigestible cellulose, pentosans, lignins and such components in food. Food fibre aids digestion and protects the body against colon cancer, diabetics and cardiovascular illness (Egbuonu and Nzewi, 2016).

There was significant ($p<0.05$) difference in the fat content of the samples which ranged from 18.48% to 34.32%. The fat content was highest (34.32%) in sample 101 (GC100%), while the lowest value was recorded in sample 606 (GC50%: PPF50%). There was decrease in the fat content with increase in pigeon pea substitution. The fat content of the flakes containing high proportion of groundnut cake is quite high which might result to decrease in the keeping quality of the products since high fat increases the chances of rancidity. However, high lipid helps improve mouth-feel and flavor of products (Coppin and Pike, 2001).

The ash content of the samples ranged from 3.06% to 4.19%. Sample 606 (GC50%: PPF50%) had the highest ash value (4.19%), while sample 101 (GC100%) had the lowest value. The values were significantly different ($p<0.05$) from each other. The value obtained indicated that the value increased with increase in pigeon pea incorporation. The ash content in pigeon pea is higher than that of groundnut and could be responsible for the increase in the ash obtained (Akinoso *et al*., 2016). It then follows that incorporation of pigeon pea in the process of snack making could enhance the mineral intake of many people, as ash is indicative of the amount of minerals contained in any food sample. Ash content depends on the quality of the flour and thus corresponds to the higher mineral content especially potassium. Ash content is a reflection of mineral status, though contamination can indicate a high concentration in a sample (Akinoso *et al*., 2016).

The carbohydrate content of the groundnut-pigeon pea snacks ranged from 26.99% to 53.28%. There was significant ($p<0.05$) difference in the carbohydrate content of the samples. The highest carbohydrate content (53.27%) was recorded in sample 606 (GC50%: PPF50%), while sample 101(GC100%) recorded the lowest value. There was increase in carbohydrate content with increase in pigeon pea inclusion. Carbohydrate refers to the starch and sugar component of flour. They are the body's preferred sources of energy because they are easily digested into glucose or blood sugar (Appiah *et al.,* 2011).

Energy value of the samples ranged from 449.18kcal to 532.00kcal with sample 101(GC100%) having the highest value (532.00kcal) while sample 606 (GC50%: PPF50%) had the lowest value. There was significant ($p<0.05$) difference among the samples. Good energy balance from various nutritional components of a food is important. The energy value of the flakes is above the recommended energy values of (360- 400kcal/100g) of food (Sharma and Chauhan, 2000).

Mineral Composition of Snacks from Groundnut Cake and Pigeon Pea Flour

The mineral contents of groundnut-pigeon pea flakes are shown in Table (4). The calcium content of the snacks ranged from 90.15 mg/100g to 114.72 mg/100g and were significantly ($p<0.05$) different from each other. The calcium content increased with increased proportion of pigeon pea flour. The values obtained suggest that the consumption of every 100g of the snacks would result in calcium intake that are lower than the FAO/WHO recommended daily intake of calcium for different target consumers such as infants and children from 0 to 9 years (300 to 700mg/day) and adolescent from 10 to 18 years (1300 mg/day), adult from 19+ years (1000 to 1300 mg/day), pregnant woman (1200 mg/day), and 1000 mg/day for lactating women (FAO/WHO, 1998). Although the improved calcium contents of the formulated blends are below the recommended values, consumption of the snacks can add to the calcium intake of the people. Calcium promotes bone formation, contraction of muscles and assists in blood clotting. The magnesium content of the snacks showed significant ($p<0.05$) difference and ranged from 143.11 mg/100g to 151.86mg/100 g. The magnesium content of the composite snacks increased as the proportion of the pigeon pea flour increased. However, the values are above the recommended magnesium intake for infant and children (26mg/day to 100mg/day), below that of adolescent (230mg/day for females and 220mg/day for males) and adults (220mg/day for females and 260mg/day for males) respectively (FAO/WHO, 1998). Magnesium is needed for more than 300 biochemical reactions in the body. It helps maintain nerve functions, keep heart rhythm steady and supports a healthy immune blood and regulates blood sugar levels (Saris *et al*., 2000). Adequate magnesium intake decreases the risk of atherosclerosis, hypertension and anxiety (Chisom and Okenwa, 2021).

Phosphorous content of the snacks ranged from 304.65 mg/100g to 337.03 mg/100g. The values significantly ($p<0.05$) decreased with increased inclusion of pigeon pea flour. Sample 101

((GC100%) had the highest phosphorous value (337.03mg/100g), while 606 (GC50%: PPF50%) had the lowest value. Phosphorus is important for normal cell growth and repair, bone growth, kidney function as well as in the maintenance of blood sugar levels and normal heart contraction (Chisom and Okenwa, 2021). There were significant ($p<0.05$) differences in the potassium content which ranged from 113.46 mg/100g to 133.81 mg/100g. Sample 101 (GC100%) had the highest potassium value (133.81mg/100g), while 606 (GC50%: PPF50%) had the lowest value. Potassium is an essential element in the body system that plays a vital role in protein synthesis, nerve condition, control of heart beat, muscle contraction and synthesis of nucleic acids (Saris *et al*., 2000). Increased potassium intake helps in blood pressure reduction and balance as well as reduces the risk of stroke (WHO, 2002).

The iron content of the snacks ranged from 4.11 mg/100g to 5.03 mg/100g and the values were significantly ($p<0.05$) different. Sample 101 (GC100%) had the lowest iron value (4.11mg/100g), while 606 (GC50%: PPF50%) had the highest value. It was observed that increase in the quantity of pigeon pea flour resulted in increased iron content of the snacks. Iron is required for building of red blood cells. However, the iron content obtained in this study was close to the recommended daily intake for infants and children (5.90mg/day to 6.20mg/day), below that of adolescents (9.30mg/day to 20.70mg/day for female and 9.70mg/day to 12.5mg/day for males) and adults (19.60mg/day for females and 9.10mg/day for males) respectively (FAO/WHO, 1998). The zinc content of the snacks ranged from 2.21 mg/100g to 2.82 mg/100g with sample 101 (GC100%) having the highest value (2.82mg/100g) and sample 606 recording the least value. The values were significantly ($p<0.05$) different from each other. The result showed decrease in the zinc content of the snacks with increase in pigeon pea flour addition implying that groundnut cake is richer in zinc. Zinc plays a major role in creation of DNA, growth of cells, building proteins, healing damaged tissues and supporting a healthy immune system.

Sensory Evaluation of Snacks from Groundnut Cake and Pigeon Pea Flour

The sensory properties of the composite snacks are presented in Table (5). The score for appearance of the samples ranged from 6.50 to 7.70. Sample 303 (GC80%: PPF20%) had the highest score (7.70), while sample 505 (GC60%: PPF40%) had the lowest score. There was no significant (p>0.05) difference between samples 202, 303, 101 and 404. Also sample 505 and 606 showed no significant (p>0.05) difference. The appearance was based on the colour-appeal and the panelist showed preference for sample 303. Appearance is an important sensory attribute of any food because of its influence on acceptability. Browning in the snacks could have been caused by maillard reaction (Potter and Hotchkiss, 2006) resulting from the presence of reducing sugars, proteins and amino acids as well as caramelization due to the effect of severe heating during processing (Ndife *et al.*, 2014). The scores for taste ranged from 5.55 to7.30, with sample 303 recording the highest value (7.30) while sample 505 the least value. There was no significant (p>0.05) difference between sample 101, 202, 303, 404 and 606 in taste. Only sample 505 was significantly (p<0.05) different from the other samples and was neither liked nor disliked.

The result of texture ranged from 6.10 to 7.35. Sample 303 had the highest score (7.35) while sample 505 had the lowest (6.10). The result showed that sample 303 had improved texture. The aroma of the snacks ranged from 6.55 to 7.40. No significant (p>0.05) difference was statistically observed among the samples. The control, sample 101 had the highest value (7.40) while sample 505 had the lowest value for aroma. General acceptability scores of the samples ranged from 6.10 to 7.75 with sample 303 recording the highest value (7.75) while sample 505 had the lowest (6.10). The result showed that all the samples were accepted as none was rejected. However, sample 303 (GC80: PPF20%) was most preferred.

CONCLUSION

The study has shown that snacks of desirable nutritional quality can be produced from groundnut cake and pigeon pea flour. The high protein and mineral content of the snacks could help in combating protein malnutrition and mineral deficiencies especially in developing countries. The snacks produced can be eaten by population of all age groups. This study has opened a new food application for pigeon pea and groundnut seeds which could be of interest in non-wheat producing countries and people with gluten intolerance. Extrusion cooking method is recommended in the production of legume based snacks because it improves protein quality, reduces anti-nutrients and enhances acceptability of product. Also, shelf-life stability of the snacks is recommended for further study.

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APPENDICES

Table 1: Blending of groundnut cake and pigeon pea flour (%)

Sample codes	Groundnut cake	Pigeon pea flour
101	100	0
202	90	10
303	80	20
404	70	30
505	60	40
606	50	50

Table 2: Functional properties of groundnut cake and pigeon pea flour blends

Sample	BD (g/ml)	WAC (g/g)	OAC (g/g)	FC (%)	FS (%)	SI (%)
101	$0.68^{f}\pm0.01$	$2.51^{a}\pm0.01$	$0.95^{a}\pm0.00$	$21.48^{f}\pm0.01$	$91.32^{a}\pm0.03$	$38.53^{f}\pm0.01$
202	$0.71^{e}\pm0.01$	$2.43^{b}\pm0.00$	$0.92^{b}\pm0.01$	$23.81^{e}\pm0.01$	$87.42^{b}\pm0.03$	$41.14^{e}\pm0.02$
303	$0.75^{d}\pm0.00$	$2.22^{c}\pm0.02$	$0.90^{c}\pm0.00$	$24.66^{d}\pm0.02$	$84.31^{c}\pm1.42$	$42.81^{d}\pm0.01$
404	$0.79^{c}\pm0.01$	$2.11^{d}\pm0.01$	$0.88^{d}\pm0.00$	$25.12^{c}\pm0.01$	$82.62^{d}\pm0.02$	$44.05^{c}\pm0.03$
505	$0.85^{b}\pm0.01$	$1.97^{e}\pm0.01$	$0.84^{e}\pm0.01$	$25.88^{b}\pm0.01$	$80.56^{e}\pm0.04$	$46.38^{b}\pm0.01$
606	$0.88^{a}\pm0.00$	$1.81^{f}\pm0.01$	$0.80^{f}\pm0.00$	$27.25^{a}\pm0.02$	$77.31^{f}\pm0.01$	$50.22^{a}\pm0.03$

a-f: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($p<0.05$). BD (bulk density), WAC (water absorption capacity), OAC (oil absorption capacity) SI (swelling Index), FS (foam stability), FC (foaming capacity)

Key: 101 = 100% groundnut flour, 202 = 90% groundnut flour: 10% pigeon pea flour, 303 = 80% groundnut flour: 20% pigeon pea flour, 404 = 70% groundnut flour: 30% pigeon pea flour, 505 = 60% groundnut flour: 40% pigeon pea flour and 606 = 50% groundnut flour: 50% pigeon pea flour

Table 3: Proximate composition of flakes from groundnut cake and pigeon pea flour

Samples	Moisture (%)	Crude Protein (%)	Crude Fibre (%)	Fat (%)	Crude Ash (%)	Carbohydrate (%)	Energy value (kcal)
101	4.18^a±0.02	28.81^a±0.01	2.61^f±0.01	34.32^a±0.02	3.06^f±0.01	26.99^f±0.05	532.00^a±0.00
202	3.85^b±0.04	26.79^b±0.01	2.82^e±0.01	31.56^b±0.01	3.29^e±0.01	31.71^e±0.01	517.98^b±0.00
303	3.64^c±0.05	24.53^c±0.01	2.97^d±0.01	30.06^c±0.02	3.41^d±0.01	35.42^d±0.01	510.26^c±1.41
404	3.26^d±0.05	22.12^d±0.01	3.14^c±0.01	26.29^d±0.01	3.71^c±0.03	41.50^c±0.01	491.01^d±0.00
505	3.03^e±0.02	20.08^e±0.02	3.48^b±0.02	23.60^e±0.01	3.96^b±0.02	45.87^b±0.01	476.18^e±0.71
606	2.85^f±0.03	17.45^f±0.01	3.77^a±0.02	18.48^f±0.02	4.19^a±0.01	53.28^a±0.01	449.18^f±0.00

a-f: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($p<0.05$).

Key: 101 = 100% groundnut flour, 202 = 90% groundnut flour: 10% pigeon pea flour, 303 = 80% groundnut flour: 20% pigeon pea flour, 404 = 70% groundnut flour: 30% pigeon pea flour, 505 = 60% groundnut flour: 40% pigeon pea flour and 606 = 50% groundnut flour: 50% pigeon pea flour

Table 4: Mineral composition of flakes from groundnut cake and pigeon pea flour

Sample	Ca (mg/100g)	Mg (mg/100g)	P (mg/100g)	K (mg/100g)	Fe (mg/100g)	Zn (mg/100g)
101	90.15^f ±0.01	143.11^f±0.01	337.03^a ±0.02	133.81^a ±0.01	4.11^f ±0.01	2.82^a ±0.01
201	92.05^e ±0.02	145.28^e±0.02	321.57^b ±0.02	129.61^b ±0.01	4.38^e±0.02	2.79^b±0.01
301	96.36^d±0.02	146.02^d±0.01	320.17^c±0.04	126.86^c±0.04	4.48^d±0.01	2.64^c±0.01
401	99.53^c±0.03	147.38^c±0.02	318.53^d±0.03	123.57^d±0.04	4.68^c ±0.01	2.52^d ±0.01
501	101.82^b±0.02	150.61^b±0.01	314.31^e±0.01	120.12^e±0.02	4.86^b±0.03	2.45^e±0.01
601	114.72^a±0.02	151.86^a±0.02	304.65^f ±0.04	113.46^f±0.03	5.03^a ±0.01	2.21^f±0.01

a-f: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($p<0.05$).

Key: 101 = 100% groundnut flour, 202 = 90% groundnut flour: 10% pigeon pea flour, 303 = 80% groundnut flour: 20% pigeon pea flour, 404 = 70% groundnut flour: 30% pigeon pea flour, 505 = 60% groundnut flour: 40% pigeon pea flour and 606 = 50% groundnut flour: 50% pigeon pea flour

Table 5: Sensory properties of flakes from groundnut cake and pigeon pea flour

Sample	Appearance	Taste	Texture	Aroma	General acceptability
101	$7.35^{ab}\pm0.93$	$7.00^{a}\pm1.38$	$7.00^{ab}\pm1.78$	$7.40^{a}\pm1.50$	$7.70^{a}\pm1.08$
202	$7.60^{a}\pm0.94$	$6.50^{ab}\pm1.76$	$7.15^{ab}\pm1.57$	$7.10^{a}\pm1.21$	$7.30^{ab}\pm1.13$
303	$7.70^{a}\pm0.98$	$7.30^{a}\pm1.22$	$7.35^{a}\pm0.99$	$7.35^{a}\pm1.57$	$7.75^{a}\pm0.91$
404	$7.15^{ab}\pm1.63$	$6.25^{ab}\pm2.24$	$7.20^{ab}\pm1.58$	$6.75^{a}\pm1.89$	$7.10^{ab}\pm1.80$
505	$6.50^{b}\pm1.64$	$5.55^{b}\pm1.79$	$6.10^{b}\pm1.80$	$6.55^{a}\pm1.64$	$6.10^{c}\pm1.37$
606	$6.60^{b}\pm1.70$	$6.15^{ab}\pm1.60$	$6.30^{ab}\pm2.11$	$6.95^{a}\pm1.79$	$6.60^{bc}\pm1.79$

a-f: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($p<0.05$).

Key: 101 = 100% groundnut flour, 202 = 90% groundnut flour: 10% pigeon pea flour, 303 = 80% groundnut flour: 20% pigeon pea flour, 404 = 70% groundnut flour: 30% pigeon pea flour, 505 = 60% groundnut flour: 40% pigeon pea flour and 606 = 50% groundnut flour: 50% pigeon pea flour