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CHEMICAL COMPOSITION AND SENSORY CHARACTERISTICS OF FERMENTED CONDIMENTS PRODUCED FROM SOYBEAN, BAMBARA NUT AND PIGEON PEA SEEDS BLENDS

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ABSTRACT
This study evaluated the chemical composition and sensory characteristics of fermented condiments produced from blends of soybean, bambara nut and pigeon pea. The soybean, bambara nut and pigeon pea fermented using banana leaves were formulated and designated as 100:0:0 (SBPB), 60:25:15 (SBPB1), 40:35:25 (SBPB2), 20:45:35 (SBPB3) and 10:55:35 (SBPB4), where sample SBPB served as the control. Proximate, mineral and sensory properties of the condiments were determined using standard methods. The proximate results showed significant ($p<0.05$) differences among the samples. The mineral results indicated increase in calcium, iron, zinc and reduction in magnesium and potassium with higher proportion of bambara nut and pigeon pea in the blend. Sensory evaluation results showed significant ($p<0.05$) differences in texture, appearance and overall acceptability, with sample SBPB4, containing 10% soybean, 55% bambara nut and 35% pigeon pea recording the highest scores for all the attributes assessed. Therefore, nutritious and acceptable fermented condiments can be produced from the blends of soybean, bambara nut and pigeon pea.

Keywords: Condiments, fermented, banana leaves, soybean, bambara nut, pigeon pea
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INTRODUCTION

Condiments are those ingredients added during food preparation which impart distinctive flavor and aroma to foods and which also contribute some proteins, carbohydrates, fats, fibre, vitamins and minerals and sometimes phytochemicals to foods (Arukwe and Onyeneke, 2020). They can also act as texture improvers and as meat supplements due to their high protein content. Fermented condiments are locally prepared in homes using the uncontrolled solid-substrate fermentation. Local condiments are produced by fermenting some grain legumes to yield high glutamic amino acid which adds flavor and typical aroma to food. Fermented condiments contribute to the macronutrients and micronutrients intake of the people. Earlier researchers have reported some local condiments produced from fermented melon and groundnut blends (Nwosu and Ojimelukwe, 1993; Arukwe and Onyeneke, 2020), fermented pigeon pea and soybean (Omafuvbe *et al*., 2004), etc., which are used to season foods especially in the rural areas.

Soybean (*Glycine max*) is a good source of plant proteins complementing cereal proteins and consumed in many countries of the world (Yang *et al*., 2011). It is produced mostly by countries such as USA, Brazil, and Argentina (USDA, 2016). Soybean and its products have been reported to lower the risks of cancer and cardiovascular diseases (Butler *et al*., 2007). Bambara nut (*Vigna subterranea*) is an underutilized legume of the family Fabaceae widely grown in Africa. It is also taken as a snack or used to make flour or made into a steamed paste (pudding) called okpa. Pigeon pea (*Cajanus cajan*) is grown in many parts of Nigeria. It is one of the underexploited seeds in Nigeria. According to Sharma *et al*. (2011), pigeon pea is a good source of protein for the poor communities in many tropical and sub-tropical regions of the world. It is also rich in dietary fibre, minerals and vitamins (Nwanekezi *et al*., 2017; Arukwe & Nwanekezi, 2022).

The common condiments used in Nigeria containing monosodium glutamate are chemical based and synthetic, and their cumulative residues in the body constitute health risk to the consumers. Not long ago in Nigeria, there were controversial publications and debates over the use of seasoning cubes and monosodium glutamate as cancer inducing agents (Okwunodulu *et al*., 2020). There is therefore the need to produce a variety of local condiments to safeguard the health of consumers and widen choices for the ever growing population and civilization, and also the need to add value to the underexploited legumes (pigeon pea, bambara nut and soybean) to produce industrial food ingredients for economic gains to the processors and farmers and help to check protein malnutrition in Nigeria. The objective of this research was to produce fermented condiments from blends of soybean, bambara nut and pigeon pea and evaluate the chemical composition and sensory characteristics.

MATERIALS AND METHODS

Sources of Raw Materials

Soybean, bambara nut and pigeon pea seeds utilized for this research were purchased from Ubani main market in Umuahia North Local Government Area, Abia State. Reagents used for analyses were obtained from Analytical Laboratory of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State.

Sample Preparation

One kilogram of each seeds of soybean, bambara nut and pigeon pea were individually sorted and extraneous materials removed and then washed with water. The seeds of soybean, bambara nut and pigeon pea were separately soaked in water overnight and the water drained. The grains were thereafter boiled in water for 1h and the water drained, and the seeds were then dehulled and kept aside. The cotyledons of soybean, bambara nut and pigeon pea were then proportioned into five samples as shown in Table 1. Each of the samples was coarsely grinded and boiled in water at $100^{o}C$ for one hour and the water drained. Each of the proportioned samples was wrapped with banana leaves (blanched over the fire) and left to ferment for 4 days. After fermentation, each sample was grinded, molded, dried, cooled and packaged in polyethylene bag for analysis.

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Formulation of Fermented Condiments from Soybean-Bambara Nut-Pigeon Pea

Table 1 shows the five samples formulated with soybean, bambara nut and pigeon pea fermented using banana leaves, where sample SBPB served as the control.

Proximate Analysis of the Condiments

Determination of Moisture Content

The AOAC (2010) method was used to determine the moisture content of the samples. Two grams of each sample was weighed into a separate moisture container. They were then placed in an oven at 150^{o}C for 3 hours, with drying stopping when two consecutive results varied by 0.001. After which they were chilled in a desiccator and weighed. The moisture content of the samples 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.

Determination of Ash Content

The ash content of the samples was determined using the technique specified by AOAC (2010). Before weighing, the porcelain crucible was dried and chilled in desiccators. Two grams of each sample was placed into the crucible and the weight was recorded. The sample was put in the crucible and heated at 550^{o}C in the muffle furnace for 3 hours. The muffle furnace was then allowed to cool before the crucibles were removed, cooled, and weighed. The following formula was used to compute the ash content:

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

Where: W_2 = weight of crucible + ash,
W_1 = weight of empty crucibl**e.**

Fat Content Determination

The fat content of the samples was determined using solvent extraction in a soxhlet apparatus, as described by the AOAC (2010). Each sample was wrapped in filter paper and placed in a soxhlet reflux flask connected to an upper condenser and a weighted oil extraction flask containing 200ml of petroleum ether. When the ether boiled, the vapour condensed into the reflux flask, completely immersing the samples for extraction. When the reflux flask was filled, syphons conveyed the oil extract back to the boiling solvent in the flask. Before removing the deffated samples, the process of boiling, condensation, and reflux was allowed to run for four hours. The oil extract in the flux was dried in an oven at 60 degrees Celsius for thirty minutes before being weighed.

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \text{ x } 100$$

Crude Fibre determination

The samples' crude fibre content was assessed using the AOAC (2010) methodology. A 200ml solution containing 1.25g of tetraoxosulphate (vi) acid (H2SO4) per 100ml of solution was used to boil two grams of each sample at reflux for 30 min. A flaunted funnel was used to filter the solution through linen, which was then washed in water to remove any remaining acidity.The residue was then put in a beaker and boiled for 30 min in 100 ml of the solution. The remaining residue was filtered through a thin but closer pad of washed and burnt asbestos in a Gosh crucible. The residue was then dried and weighed in an electric oven. The waste was incinerated, cooled, and weighed. The crude fibre content of the sample 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

Determination of Crude Protein

The Kjedahl technique, as described by the AOAC (2010) was used to assess the samples' crude protein content. The digestion flask was filled with one gram of the material. The sample was supplemented with Kjedahl catalyst (tablets of selenium). A clear solution was produced after adding 20ml of concentrated sulfuric acid to the sample and fastened to the digester for 8 h resulting in a clear solution. The total percentage of protein was calculated:

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

Determination of Carbohydrate Content

The AOAC (2010) described formula was employed for the samples' carbohydrate content determination.

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

Mineral Analysis of the Condiments

The mineral contents of the condiments were determined using the AOAC (2005) method. The samples were dry ashed and the ash was dissolved with 20ml of dilute hydrochloric acid, filtered with Whatman No. 4, the filtrate was made up to 100ml using deionized water in a graduated cylinder. Calcium, magnesium, iron and zinc were determined in 10ml aliquots of the filtrates using atomic absorption spectrophotometer (Perkin-Elmer 410021, USA). Potassium content was determined with a flame photometer (Jenway PFP7, UK).

Sensory Evaluation of the Condiments

A 7-point Hedonic scale as described by Iwe (2014) was used to assess the sensory characteristics of the condiments by a semi-trained test panel of 20 judges from the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike. In the

Hedonic scale, 1 translates to dislike extremely, whereas 4 and 7 connotes neither like nor dislike and like extremely respectively. This was used to evaluate the appearance, taste, texture, aroma, and overall acceptability of the condiments. The panellists were instructed to rinse their mouths with water after tasting every sample and not to make comments during evaluation to prevent influencing other panellists. They were also asked to comment freely on samples on the questionnaires given to them.

Experimental Design

A completely randomized design was used for this study.

Statistical Analysis

Data was analysed using one-way analysis of variance with the aid of Statistical Product of Service Solution version 21.0. Treatment means were separated using Duncan multiple range test at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSION

Proximate Composition of Fermented Condiments from Blends of Soybean, Bambara Nut and Pigeon Pea

The proximate composition of fermented condiments from blends of soybean, bambara nut and pigeon pea is presented in Table 2. The moisture content of the samples ranged from 6.80% to 7.12%. There were significant ($p<0.05$) differences in the moisture content of the samples except for samples SBPB3 and SBPB4 which did not differ significantly. The moisture content of the samples increased with the increasing proportions of bambara nut and pigeon pea. It was observed that the moisture content of all the condiments were lower than the recommended moisture content (< 10%) for safe food storage (FAO/WHO, 1998), suggesting that the condiments would have shelf stability under favourable conditions. Moisture in foods helps the solubility of ingredients, although high moisture content can make the product more liable to spoilage or attack by microorganisms.

The protein content of the fermented condiments ranged from 26.00% to 35.50%. Protein content was highest in the control sample (100% soybean) and lowest in sample SBPB4. However, the protein content decreased as the level of substitution of soybean with bambara nut and pigeon pea increased. All the condiments produced from soybean, bambara nut and pigeon pea were high in protein (26.00% – 35.50%). The high protein content recorded implies that the condiments could be useful as a cheap source of dietary protein for the poor who find it difficult to afford animal protein. Protein availability in foods helps to build and maintain healthy muscle mass, while also supporting tendon, ligaments and other body-tissue. It is also important for the regulation and maintenance of fluid and electrolyte balance in the body and coordinates bodily functions (Arukwe *et al*., 2022).

Highest fat content was recorded for sample SBPB (23.64%) which progressively decreased as the proportion of bambara nut and pigeon pea increased and the least fat content was recorded for sample SMPB4 (16.12%) with all samples showing significant ($p<0.05$) differences. The reduction in fat content with the increased inclusion of bambara nut and pigeon pea to soybean is advantageous since high fat can negatively affect shelf-stability of the product because fat can undergo oxidative deterioration leading to rancidity and spoilage. Fat provides energy, increases food palatability and aids the absorption of fat-soluble vitamins (Makinde and Oladipo, 2012).

The fibre content of the fermented condiments ranged from 4.10 to 5.90%, and this steadily increased as the level of bambara nut and pigeon pea increased in the blends. The highest fibre was recorded for sample SBPB4 (5.90%) while the least value was recorded in sample SBPB (control). The increase in crude fibre content of the fermented condiments observed with the increase in the proportion of bambara nut and pigeon pea is expected because it has been reported that pigeon pea is high in fibre (Nwanekezi *et al*., 2017). Crude fibre offers a variety of health benefits and is essential in reducing the risk of chronic diseases such as diabetes, obesity, cardiovascular disease and diverticulitis. Crude fibre lowers the concentration of low-density lipoprotein cholesterol in the blood, possibly by binding with bile's acids (Ishiwu and Tope, 2015).

The ash content of the fermented condiments followed the same trend of increase with increased incorporation of bambara nut and pigeon pea in the blend, and ranged between 4.26% and 7.65%. The increased ash content as the level of bambara nut and pigeon pea increased in the blend implies that, Sample SBPB4 with the highest ash content may supply minerals to the body when consumed than the other samples. Nwanekezi *et al*. (2017) reported increase in ash content of pigeon pea due to fermentation.

The carbohydrate content of the fermented condiments ranged between 25.70% and 37.21% and progressively increased with the rise in the addition of bambara nut and pigeon pea in the blend. The increase in carbohydrate content observed in the samples with the rise in the inclusion of bambara nut and pigeon pea could be attributed to the higher carbohydrate content of bambara nut and pigeon pea compared to soybean. Soybean contains high quantity of protein which ranks highest among the food crops (Iwe, 2003) and less carbohydrate. Carbohydrates play important role in the body mechanism such as supplying of energy, serving as mild natural laxative and sparing proteins as energy source (Gaman and Sherrington, 1996; Gordon, 2000).

Mineral Content of Fermented Condiments from Blends of Soybean, Bambara Nut and Pigeon Pea

Table 3 depicts the mineral composition of the fermented condiments produced from the blends of soybean, bambara nut and pigeon pea. The calcium content significantly ($p<0.05$) increased with the rise in the proportion of bambara nut and pigeon pea in the blend, and ranged between 615.00 mg/100g and 1120.22 mg/100g. The highest calcium content was recorded in sample SBPB4 while the control sample (SBPB) had the least value. The increase observed in the calcium content with the increase in the incorporation of bambara nut and pigeon pea indicates that soybean is lower in calcium. This observation justifies the assertion of Nwanekezi *et al*.

(2017) that pigeon pea is high in calcium. Bambara nut has also been reported to be a good source of calcium (Oyeyinka *et al.*, 2018). Arukwe and Onyeneke (2020) also reported high mineral contents for fermented condiments prepared with melon and groundnut seeds. Calcium is important for building strong bones and teeth, nerve transmission, muscle function, blood clotting and helps in conversion of food into energy (Fallon and Enig, 2007).

The magnesium content of the fermented condiments significantly ($p<0.05$) decreased with the increase in bambara nut and pigeon pea supplementation ranging between 410.20 mg/100g and 463.00mg/100g. The decrease in magnesium content observed with increase in the level of substitution with bambara nut and pigeon pea could be due to the fact that soybean is richer in magnesium than bambara nut and pigeon pea. However, all the samples magnesium content (410-463 mg/100 g) met the recommended daily intake of magnesium of 170mg/day for children and 350mg/day for adults (Mason, 2008). Magnesium is required for energy production, oxidative phosphorylation and glycolysis. It contributes to the structural development of bone, blood vessels and essential in nerve and muscle activities (Soetan *et al*., 2010).

There were significant ($p<0.05$) differences in the potassium content of the fermented condiments which ranged from 1801.15mg/100g to 2052.12mg/100g with samples SBPB4 and SBPB recording the least and highest values respectively. The potassium content of the samples significantly ($p<0.05$) decreased with the rise in the inclusion of bambara nut and pigeon pea. The reduction observed in the potassium content with the rise in the addition of bambara nut and pigeon pea suggests that soybean is a better source of potassium compared to bambara nut and pigeon pea. However, the values obtained for potassium in this study were close to the recommended daily allowance (2000mg/day) of potassium for adults (Wardlaw and Kessel, 2002) whereas sample SBPB (2052.12mg/100g) met the RDA for potassium. Potassium is necessary for absorption of protein and other minerals like calcium in the body (Niba *et al*., 2009). It is also important for proper fluid balance, nerve transmission and muscle contraction (Yusuf *et al*., 2014).

The iron content of the fermented condiments recorded significant ($p<0.05$) increment with the rise in the addition of bambara nut and pigeon pea in the blend. The control condiment (SBPB) had the lowest value (17.20 mg/100 g) while sample SBPB4 recorded the highest value (84.30 mg/100g). The increased iron content with the rise in the proportion of bambara nut and pigeon pea in the blend indicates that the blended condiments will contribute to checking iron deficiency anemia in the population. Iron is important for the synthesis of haemoglobin and myoglobin, which are oxygen carriers in the blood and muscle respectively (Cook *et al*., 1997; Khush, 2001).

The zinc content of the fermented condiments followed the same trend of increment with the inclusion of bambara nut and pigeon pea, and ranged between 12.55 mg/100g and 13.50 mg/100g with the control sample (SBPB) and sample SBPB4 having the least and highest values respectively. The observed increase in the zinc content with the increase in the proportion of bambara nut and pigeon pea is beneficial because the mineral, zinc, is needed for the immune system to work properly. Zinc is important for cell division, cell growth, wound healing and breaking down of carbohydrates (Singh *et al*., 2011). The values for zinc observed in this study met the recommended daily allowance of zinc for men and women being (9.4mg/day) and (6.8mg/day) respectively (FNB, 2001).

Sensory Properties of Fermented Condiments from Blends of Soybean, Bambara Nut and Pigeon Pea

Table 4 presents the sensory evaluation results of the fermented condiments prepared from blends of soybean, bambara nut and pigeon pea. The sensory evaluation results of the fermented condiments showed that they were all accepted going by the 7-point hedonic scale. This suggests that the condiments produced in this study were not only nutritious but also accepted. The scores for texture of the condiments progressively increased with the rise in the inclusion of bambara nut and pigeon pea in the blend. The control sample (100% soybean) had the lowest value for texture (5.00) while sample SBPB4 had the highest value (6.10). The improved texture observed with increased supplementation with bambara nut and pigeon pea could be because of pigeon pea which has been reported to improve the textural characteristics of products (Arukwe *et al*., 2022). The scores for taste (5.87-5.89) of the condiments also recorded progressive increment with increase in the proportion of bambara nut and pigeon pea in the blend but were not significantly (p>0.05) different from each other.

The high protein content recorded for all the condiments might be the reason for the marginal difference in their taste. The aroma of the condiments ranged between 5.84 and 5.85 with no significant (p>0.05) difference among the samples. The similar aroma observed for all the samples could be due to their high protein content since protein is the main source of aroma in fermented condiments. Ouoba *et al*. (2005) opined that protein is the main substrate responsible for the emission of aromatic substances peculiar to fermented condiments by the fermenting microorganisms. The scores for appearance and overall acceptability of the samples followed same trend of progressive increase with the rise in the addition of bambara nut and pigeon pea in the blends. The enhanced appearance can be attributed to the increased content of bambara nut and pigeon pea. Appearance is an important sensory characteristic which affects consumer's preferences. Overall acceptability indicates the consumer's acceptance of the food product, and the condiment, sample SBPB4, had the highest score for this attribute. Overall acceptability is also the cumulative effect of the other attributes considered. The scores recorded for all the attributes assessed showed that the panellists preferred the sample with the highest proportion of bambara nut and pigeon pea (sample SBPB4).

CONCLUSION

This study has revealed the high nutrient content of the fermented condiments produced from the combinations of the underexploited legumes, soybean, Bambara nut and pigeon pea. It was observed that the blended fermented condiments had improved nutritional composition and sensory acceptability more than the control sample (soybean) and can contribute in checking the protein-energy and micronutrient malnutrition in the society especially among the rural poor. Therefore, consumption of locally fermented condiments is recommended in place of the artificial condiments containing monosodium glutamate. Further studies on the antinutrients and vitamins content of the condiments are also recommended.

REFERENCES

Ajani, A. O., Osundahunsi, O. F., Akinoso, R., Arowura, K. A., Abiodun, A. A. & Pessu. P. O. (2012). Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Global Journal of Science Frontier Research Biological Sciences*, 12: 1-3.

AOAC (2005). The Official Methods of Analysis. (18^{th} Edition). Association of Official Analytical Chemist. Washington D.C., U.S.A., PP.223-225.

AOAC (2010). Official Method of Analysis. 18^{th} Edition. Association of Official Analytical Chemists, Washington DC, USA.

Arukwe, D. C. & Nwanekezi, E. C. (2022). Assessment of the mineral composition and vitamin content of blends of sorghum (*Sorghum bicolor* L.) and pigeon pea (*Cajanus cajan* L.) flours. *World Journal of Advanced Research and Reviews*, 14(01): 534-540.

Arukwe, D. C. & Onyeneke, E. N. (2020). Evaluation of mineral, vitamin and phytochemical composition of ogiri from melon and groundnut seeds. *Nigerian Food Journal*, 38(2): 46-52.

Arukwe, D. C., Arukwe, R. C., Obeta, A. O. & Agwo, O. E. (2022). Quality evaluation and sensory properties of gari enriched with pigeon pea flour. *Nigerian Agricultural Journal*, 53(2): 150-155.

Arukwe, D. C., Offia Olua, B. I. & Ike, E. A. (2022b). Proximate composition, functional properties and sensory attributes of gruels prepared from blends of sorghum and pigeon pea flours. *InternationalJournal of Home Economics, Hospitality and Allied Research*, 1(2): 361-375.

Butler, P. C., Meier, J. J., Butler, A. E. & Bhushan, A. (2007). The replication of cells in normal physiology, in disease for therapy. *Nature Clinical Practice Endocrinology and Metabolism*, 3: 758-768.

Cook, J. D., Reddy, M. B., Burn, J, Juillerat, M. A.& Hurrel, R. F. (1997). The influence of different cereal grains on iron absorption from infant cereals. *American Journal of Clinical Nutrition*, 65: 964-969.

Fallon, S. & Enig, M. G. (2007). Nourishing Tradition In: The Cookbook that Challenges Politically Correct Nutrition and the Diet Directorates. New Trends Publishing Inc. www.newtrendspublishing.com

FAO/WHO (1998). Preparation and use of food-based dietary guidelines. Report of a joint FAO/WHO Consultation. WHO Technical Report Series 880. Geneva.

FNB – Food and Nutrition Board (2001). Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. National Academy Press, Washington DC.

Gaman, P. M. & Sherrington, K. B. (1996). The Science of Food. 4^{th}. Ed. Reel Educational and Professional Publisher Limited, Oxford, pp. 125-136.

Gordon, M. N. (2000). Contemporary Nutrition: Issues and Insights. 4^{th} ed. Mc-Graw Hill Companies, New York, pp. 102-256.

Ishiwu, C. N. & Tope, V. A. (2015). Effect of period of fermentation on nutrients of castor oil seed (*Ricinus communis*). *Direct Research Journal of Agriculture and Food Science*, 3(10): 178-183

Iwe, M. O. (2003). The Science and Technology of Soybean. Rejoint Communication Services Limited, Enugu, pp. 3-31.

Iwe, M. O. (2014). Current Trends in Sensory Evaluation of Foods. Revised Edition. Rojoint Communication Services Ltd. Uwani Enugu, Nigeria.Pp. 144-145.

Khush, G. S. (2001). Challenges for meeting the global food and nutrient needs in the new millennium. Proceedings of the Nutrition Society, 60: 15-26.

Makinde, F. M. & Ladipo, A. T. (2012). Physico-chemical and microbial quality of sorghum based complementary food enriched with soybean (*Glycine max*) and sesame (*Sesanum indicum*). *Journal of Food Technology*, 10: 46-49.

Mason, J. B. (2008). Vitamins, trace minerals and other micronutrients. In: Goldman L, Ausiello DA (eds) Cecil medicine, vol 225, 23^{rd} edn. Saunders Elsevier, Philadelphia, 1-11.

Niba, L. L., Bokanga, M. M., Jackson, E. L., Schlimme, D. S., &Li. B. W. (2009). Physiological properties and starch granular characteristics of flour from various *Manihot esculenta* (cassava) genotypes. *Journal of Food Science*, 67(5): 1701-1705.

Nwanekezi, E. C., Ubbaonu, C. N., &Arukwe, D. C. (2017). Effect of combined processing methods on the proximate and mineral composition of pigeon pea (*Cajanus cajan*) flour. *International Journal of Food Science and Biotechnology*, 2(4): 73-79.

Nwosu, C. D. and Ojimelukwe, P. C. (1993). Improvement of the traditional method of ogiri production and identification of the micro-organisms associated with the fermentation process. *Plant Foods for Human Nutrition*, 43(3): 267-272.

Okwunodulu, I. N., Onwuzurike, U. A. and Agha, E. F. (2020). Nutritional properties of indigenous fermented condiment (ogiri) produced from partial substitution of castor oil bean seed (*Ricinus communis*) with soybean (*Glycine max*) seeds. *Nigerian Journal of Biotechnology*, 37(2): 32-46.

Omafuvbe, B. O., Olumuyiwa, S. F., Osuntogu, B. A., & Adewusi, R. A. (2004). Chemical and biochemical changes in African locust bean (*Parkia biglobosa*) and melon (*Citrullus vulgaris*) seeds during fermentation to condiments. *Pakistan Journal of Nutrition*, 3(3): 140-145.

Ouoba, L. I. I., Diawara, B., Annan, N. T., Poll, L., &Jakobsen, M. (2005). Volatile compounds of soumbala, a fermented African locust bean (*Parkia biglobosa*) food condiment. *Journal of Applied Microbiology*, 99(6): 1413-1421.

Oyeyinka, S. A., Tijani, T. S., Oyeyinka, A. T., Arise, A. K., Balogun, M. A. & Kolawole, F. L. et al. (2018). Value added snacks produced from Bambara groundnut (*Vigna subterranea*) paste or flour. *LWT-Food Science and Technology*, 88: 126-131.

Sharma, S., Agarwal, N. & Verma, P. (2011). Pigeon pea (*Cajanus cajan* l.): a hidden treasure of regime nutrition. *Journal of Functional and Environmental Botany*, 1(2): 91-101.

Singh, M. &Das, R. R. (2011). Zinc for the common cold. Cochrane database syst. Rev. February 16, 2011.

Soetan, K. O., Olaiya, C. O. & Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants, sourced from a market in Ogbomoso, Nigeria. *African Journal of Food Science*, 3:51-55.

USDA (2016). Gain Report. Global Agricultural Information Network. Retrieved from https://gain.fas.usda.gov/Recent%GAIN%20Publications/Oilseeds%20and%20Products20Annual-Buenos%20Aires-Argentina-44-2016.pdf

Wardlaw, G. M. & Kessel, M. W. (2002). Minerals: Dietary needs, absorption, transport and excretion: In: Perspective in Nutrition (5th ed.). Mc-Graw Hill Companies Inc., New York, 418-464.

Yang, H. Y., Park, S., Pak, V., Chung, K. R.,& Kwon, D. Y. (2011). Fermented Soybean Products and Their Bioactive Compounds. In El-Shemy, H. (Ed.) Soybean and Health. Intech Open.

Yusuf, P. A., Egwujeh, S. I. D., Damak, A., & Netala, J. (2014). Enrichment of Apula = A roasted maize meal with African yam bean and plantain flour. *Pakistan Journal of Nutrition*, 13(7): 377-380.

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APPENDICES

Table 1: Formulation of the Condiments

Samples	Soybean	Bambara Nut	Pigeon Pea
SBPB	100	0	0
SBPB1	60	25	15
SBPB2	40	35	25
SBPB3	20	45	35
SBPB4	10	55	35

Table 2: Proximate Composition of the Condiments (%)

Samples	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
SBPB	$6.80^{d}\pm0.02$	$35.50^{a}\pm0.01$	$23.64^{a}\pm0.0$	$4.10^{e}\pm0.0$	$4.26^{e}\pm0.0$	$25.70^{e}\pm0.02$
SBPB1	$6.92^{c}\pm0.01$	$33.20^{b}\pm0.0$	$20.22^{b}\pm0.0$	$4.45^{d}\pm0.01$	$4.68^{d}\pm0.02$	$30.53^{d}\pm0.0$
SBPB2	$7.01^{b}\pm0.0$	$28.70^{c}\pm0.02$	$18.15^{c}\pm0.02$	$5.00^{c}\pm0.0$	$5.85^{c}\pm0.0$	$35.29^{c}\pm0.0$
SBPB3	$7.11^{a}\pm0.0$	$26.58^{d}\pm0.01$	$17.50^{d}\pm0.0$	$5.85^{b}\pm0.01$	$7.50^{b}\pm0.01$	$35.46^{b}\pm0.01$
SBPB4	$7.12^{a}\pm0.01$	$26.00^{e}\pm0.01$	$16.12^{e}\pm0.01$	$5.90^{a}\pm0.0$	$7.65^{a}\pm0.0$	$37.21^{a}\pm0.0$

Values are Means ± standard deviation of triplicate determinations $^{a-e}$ Means bearing the same superscripts within the same rows are not significantly (P>0.05) different.

Key: SBPB= 100% soybean, SBPB1= 60% soybean, 25% Bambara and 15% pigeon pea, SBPB2= 40% soybean, 35% Bambara and 25% pigeon pea, SBPB3= 20% soybean, 45% Bambara and 35% pigeon pea and SBPB4 = 10% soybean, 55% Bambara nut and 35% pigeon pea.

Table 3: Mineral Content of the Condiments (mg/100g)

Samples	Calcium	Magnesium	Potassium	Iron	Zinc
SBPB	$615.00^{e}\pm0.02$	$463.00^{a}\pm0.01$	$2052.12^{a}\pm0.01$	$17.20^{e}\pm0.0$	$11.50^{e}\pm0.02$
SBPB1	$801.10^{d}\pm0.0$	$450.10^{b}\pm0.02$	$1960.10^{b}\pm0.0$	$25.50^{d}\pm0.01$	$12.30^{d}\pm0.0$
SBPB2	$955.01^{c}\pm0.0$	$435.10^{c}\pm0.0$	$1866.0^{c}\pm0.0$	$51.00^{c}\pm0.01$	$12.55^{c}\pm0.0$
SBPB3	$1075.10^{b}\pm0.01$	$422.00^{d}\pm0.02$	$1830.01^{d}\pm0.0$	$72.10^{b}\pm0.0$	$13.01^{b}\pm0.02$
SBPB4	$1120.22^{a}\pm0.0$	$410.20^{e}\pm0.0$	$1801.15^{e}\pm0.01$	$84.30^{a}\pm0.0$	$13.50^{a}\pm0.0$

Values are Means ± standard deviation of triplicate determinations [a-e] Means bearing the same superscripts within the same rows are not significantly (P>0.05) different.

Key: SBPB= 100% soybean, SBPB1= 60% soybean, 25% Bambara and 15% pigeon pea, SBPB2= 40% soybean, 35% Bambara and 25% pigeon pea, SBPB3= 20% soybean, 45% Bambara and 35% pigeon pea and SBPB4 = 10% soybean, 55% Bambara nut and 35% pigeon pea.

Table 4: Sensory Properties of the Condiments

Samples	Texture	Taste	Aroma	Appearance	Overall Acceptability
SBPB	5.00^{e}±0.0	5.87^{a}±0.02	5.85^{e}±0.02	5.50^{e}±0.01	5.13^{e}±0.0
SBPB1	5.50^{d}±0.01	5.88^{a}±0.0	5.85^{a}±0.01	5.73^{d}±0.0	5.45^{d}±0.01
SBPB2	5.93^{c}±0.0	5.88^{a}±0.01	5.85^{a}±0.0	6.00^{c}±0.01	5.70^{c}±0.01
SBPB3	6.05^{b}±0.01	5.89^{a}±0.0	5.84^{a}±0.0	6.50^{b}±0.0	6.12^{b}±0.0
SBPB4	6.10^{a}±0.01	5.89^{a}±0.02	5.84^{a}±0.01	6.55^{a}±0.02	6.15^{a}±0.02

Values are Means ± standard deviation of triplicate determinations [a-e] Means bearing the same superscripts within the same rows are not significantly (P>0.05) different.

Key: SBPB= 100% soybean, SBPB1= 60% soybean, 25% Bambara and 15% pigeon pea, SBPB2= 40% soybean, 35% Bambara and 25% pigeon pea, SBPB3= 20% soybean, 45% Bambara and 35% pigeon pea and SBPB4 = 10% soybean, 55% Bambara nut and 35% pigeon pea.