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Original Article

Quality evaluation and functional properties of *Kokoro* produced from maize and African yam bean flour blends

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ABSTRACT

This study was conducted to evaluate the nutritional composition of "Kokoro" produced from maize (M) and African yam bean (AYB) composite flour. Different ratios of M and AYB composite flour were formulated, ranging from Sample XWB: 100% maize flour; YVA: 95% maize flour and 5% AYB; KRM: 90% maize flour and 10% AYB; Sample PND: 85% maize flour and 15% B; and GSZ: 80% maize flour and 20% AYB. The flour and maize chips' proximate and mineral compositions were evaluated. Sensory characteristics of the maize chip were determined. The result obtained for proximate composition of flour and maize chip (M and AYB composite flour) showed a mean moisture content of 9.96% and 13.52%, crude protein of 3.13% and 0.86%, crude fat of 2.84% and 8.99%, crude fiber of 1.18% and 1.42%, total ash of 2.05% and 2.00%, and carbohydrate of 77.27% and 74.17%, respectively. The mineral composition of the maize chips contained a mean calcium of 54.00 mg/100g, magnesium of 13.75 mg/100g, iron of 2.80 mg/100g, sodium of 82.50 mg/100g, zinc of 0.01 mg/100g, and phosphorus of 33.75 mg/100g. The study showed that the nutritional quality of maize chips can be improved through the addition of AYB. This is reflected in the improved nutrition, which increased with the increase in AYB flour inclusion level. The substitution of maize with AYB significantly improved the mineral and functional properties of the blends. Sensory evaluation showed that consumers tend to prefer maize chips from 90:10 M and AYB composite flour.

KEYWORDS: *African yam bean, Flour blends, Maize, Maize-chip*

INTRODUCTION

food habits of Nigerians are rapidly changing from the traditional foods to lighter foods such as snacks (Bolade, 2018). Snack foods have been described as sweet or savory foods usually consumed to provide light sustenance in a quick and convenient format (Bolade, 2018). One peculiar characteristic of snack foods is that they are normally consumed between or as an alternative to main meals. The types of snack foods found in different localities are usually related to the food raw material availability and culture of the people. Some examples of snack foods include biscuits, meat pies and doughnuts from wheat

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flour; fried chips from potato, sweet potato or unripe plantain; fried foods from maize or cowpea paste; among others.

Maize-chip (Kokoro)are ready to eat, convenient and inexpensive snack prepared from maize flour which contains primarily carbohydrates is a popular snack made and widely accepted among children and adults of South Western Nigeria (Sade & Aderonke, 2013).There are two distinct classes of maize-chip (kokoro), sour and non-sour types. The quality of maize-chip is governed by nature and quantity of ingredients used. Physical characteristics, organoleptic properties, and nutritional quality of Maize-chip vary with different composite flour and percentage of additive used (Oranusi & Dahunsi, 2015; Fasasi & Omotayo, 2013). Maize-chip (kokoro) is traditionally produced from thick coarse corn paste. It is a ringed shaped snacks with a maximum of four rings in a package, the production of maize-chip in Nigeria takes place majorly in three villages: Imashayi, Joga, and Ibori all in Yewa North Local Government Area, Ogun state, Nigeria (Oranusi & Dahunsi, 2015).

Maize (*Zea mays L.*) is the third most important cereals in the world after rice and wheat and is ranked fourth after millet, sorghum and rice in Nigeria (Sade & Aderonke, 2013). According to Global statistics for Cereal consumption, the total consumption in African diet is 291.7g/person/day, including an average maize consumption of 106.2g/person/day (FAO, 2009). In the tropics, maize is a common cereal crop, a good source of carbohydrate, vitamins and minerals. It can be processed into a wide range of food items and snacks (FAO, 2009).

Legumes are adaptable under unfavorable ecological conditions, nutritious, and stress tolerant, possessing features for enhancing the sustainability of dry subtropical and tropical agricultural systems (Khoury, 2015). They fit in various cropping systems owing to their wide flexibility, low input requirements, and potential for nitrogen fixing and weed reduction (Sardana *et al.,* 2010). African yam bean is a plant that produces both tubers and bean seeds (legumes). African yam bean is scientifically known as *Sphenostylis stenocarpa* (Chacha, 2017). Although African yam bean has existed for long however it just be exploited for use for it reported health benefits**.** According to Khoury, (2015)**,** African yam bean contain health beneficial components like carbohydrates, protein, zinc, fat, fibre, calcium, iron, magnesium, and so on. This study intends to investigate influence of African yam bean inclusion in the quality of maize-chip.

MATERIALS AND METHODS

Materials

Whole dried maize grains, African yam bean, refined vegetable oil; onions and salt used were procured from Sabo Market in Ikorodu, Lagos State.

Samples preparation

Maize Flour was prepared using the method of Idowu & Aworh (2017). Maize samples were sorted to remove stones, dirt's and debris. The cleaned maize grains were weighed and dry milled in a hammer mill (model ED-5 Thomas Wiley, England) and sieved using 750um mesh size. Maize flour obtained was stored in an airtight container prior to analysis time.

African yam bean (AYB) flour was prepared using the method of Oluwamukomi & Akinlabi (2011). The seed were sorted and cleaned manually and washed. The African yam bean were dehulled manually to remove the husk and drained. The decorticated seeds were oven dried at (65) °C for 5h using oven (Model DHG-9101.1 SA) to reduce the moisture content of the flour. The dried seed was milled in a hammer mill (model ED-5 Thomas Wiley, England) and sieved using 750um mesh size. AYB flour was stored in an airtight container prior to analysis time.

Blends formulations

Maize flour was blended with African yam bean flour in the ratio: 100: 00 (Control): 95: 5, 90:10, 85:15, and 80:20. Sample XWB: 100% maize flour; Sample YVA: 95% maize flour and 5% African yam bean; Sample KRM: 90% maize flour and 10% African yam bean; Sample PND: 85% maize flour and 15% African yam bean and Sample GSZ: 80% maize flour and 20% African yam bean.

Preparation of Maize-chip

Chip (Kokoro) was prepared using the method of Ewulo *et al.,* (2017). Salt was added to 180g composite flour to add taste and was gently stirred into 0.5L boiling water in stainless-steel pot. The mixture was cooked with continuous stirring until stiff dough was formed. The dough was cooled to a temperature (40°C) at which it could be kneaded by hand for 5 min. The kneaded dough was cut into pieces, rolled into cylindrical shapes and deep fried at 150°C in 1L of hot refined vegetable oil for 3 min. The fried Maize-chip was then cooled and packed in sealed polyethylene bags.

Proximate Analysis

Determination of ash content

In a clean and dried porcelain crucible 4g of the sample was weighed into the crucible. The crucible was placed into the muffle furnace set at 520-550 °C. The temperature was maintained until white, light grey or reddish ash is obtained which appears to be free from carbonaceous particles. The crucible was placed in a desiccator, allowed to cool and weigh immediately. Calculation of results: CA (g/kg) = (m. - Ma).1000(m, - Ma). Crude protein was determined using Kjeldahl method as described by AAC, (2005). The moisture content, fat content, crude fibre and carbohydrate was also determined by the method as described by AOAC (2005).

Determination of mineral elements

The mineral composition of each sample was determined by wet ashing method followed by spectrophotometric reading of the level of mineral method as described by AOAC (2005). Triplicate samples (1g) of each sample were ashed in muffle furnace at 450°C for 5-6 hours. The ashed samples and silica dishes were removed and transferred into the desiccators to cool after which the samples were dissolved with1ml of 0.5% HNO3. Little distilled water was added and filtered into a clean small plastic bottle using Whatman filter. Distilled water was later added to dilute the solution up to 50ml. Atomic absorption spectrophotometer (u0k 201, VGP) was used in determining the mineral content. The mineral content was calculated using the formula: Mineral (mg/100 g) = (RxVxD/Wt) When R = Solution concentration; V = Volume of sample digested, D= Dilution factor, and Wt= Weight of sample

Sensory evaluation

Sensory evaluation was carried out on the freshly prepared samples using a panel of 16 members who were familiar with koroko. The panelists were each given five samples at a time to evaluate the effect different substitution ratio will have on the crunchiness, aroma, crispness and taste. Each panelist was asked to score each attribute on a 9-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively

Statistical Analysis

All analyses were carried out in triplicates. The results obtained were subjected to analysis of variance (ANOVA) using the statistical package for social sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA). Means were separated using the Duncan multiple range test (DMRT) at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSION

Proximate Composition of Flour Produced from Maize and African Yam Bean

The proximate composition of flour produced from maize and African yam bean are shown in Table 1. Moisture content can affect the physicochemical properties of food which directly corresponds to the freshness and stability of food products for consumers. The result from this work showed highest moisture content (11.78 %) was observed in sample GSZ while the lowest value (8.13 %) was recorded in sample YVA. The moisture content obtained in this is below 14% recommended for long period of storage, hence a good potential during storage (Adeleke & Odedeji, 2010, Ogunlakin *et al.,* 2012). Results of moisture content in this study is similar to the range 9.38 to 10.48% and 5.50% to 10.00% reported by Abioye *et al.,* (2018) and Anosike *et al.,* (2019) for composite flours of wheat, germinated finger millet flour and African yam bean. There was no significant difference ($p>0.05$) among the samples except sample PND and GSZ. The highest protein content (3.45 %) was observed in sample GSZ while the lowest value (2.80 %) was recorded in sample XWB. An increase was observed in the protein content of the composite flour with increase in African yam bean flour inclusion. This increase in protein content may be attributed to the protein properties of African yam bean flour (Idowu, 2015). Olaoye *et al.,* (2006) also observed an increase in protein content with corresponding increase in the proportion of soy flour supplementation in bread produced from composite flour of wheat plantain and soybean. The findings also agree with the report of Adebowale *et al.,* (2012) who observed an increased trend in the protein content (7.06 – 11.84%) of cookies made from sorghum – wheat flour blends. There was no significant difference ($p>0.05$) between sample XWB and YVA, sample KRM and PND respectively.

The crude fat content ranged from 2.25-3.43%. The highest crude fat content was observed in sample GSZ while the lowest value was recorded in sample PND. According to Iwe & Egwuekwe, (2010) fat improves flavour and increase the mouth feel of foods and it is a significant factor in food formulation especially in the cookies. The fat contents of the flour decrease with increase in African yam bean flour inclusion. This could be as a result of the low-fat content of African yam bean flour (Anosike *et al.,* 2019). The fat content obtained from the flour blends is lower than the recommended value (Anosike *et al.,* 2019). The decrease in fat content is of interest to consumers interested in consumption of low-fat food products. The shelf life of the blends may however be increased due to low fat content, since all fats containing foods have some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity. The fat content observed in this study was similar to the range 1.62 to 3.67 % reported by Anosike *et al.,* (2019). Significant difference ($p<0.05$) exists among the samples except sample YVA and PND among others.

The highest crude fiber content (1.53 %) was observed in sample GSZ while the lowest value (0.83 %) was recorded in sample XWB. The crude fiber was observed to increase with increase in African yam bean flour. This could be attributed to low fiber content in maize (Idowu, 2015). High fiber content in African yam bean is desirable since it may contribute to bulkiness in food and aid bowel movement and prevention of many gastrointestinal diseases in man (Satinder, *et al.,*2011). There was no significant difference ($p>0.05$) among the samples except sample KRM and GSZ respectively. The highest total ash content was observed in sample GSZ (2.55 %) while the lowest value was recorded in sample XWB (1.55 %). The ash content was observed to increase with increase in substitution level. Ash helps in the breakdown of other compounds such as fat, protein and carbohydrate (Okaka & Ene, 2015). High ash content indicates high levels of minerals in the flour that will provide more mineral nutrient to the consumers. Significant difference ($p<0.05$) exists among the samples. The highest carbohydrates (83.64 %) content was observed in sample YVA while the lowest (77.27 %) value was recorded in sample GSZ. There was no significant difference ($p>0.05$) between sample XWB and YVA, sample KRM and PND respectively. The carbohydrate content of maize- African yam bean blends decreased with increase in the level of African yam bean. This could be due to the fact that maize being a cereal is rich in carbohydrate content.

Table 1: Proximate Composition of Flour Produced from Maize and African Yam Bean

Sample	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Total Ash (%)	Carbohydrate (%)
XWB	8.50±0.18[c]	2.80±0.00[c]	3.25±0.71[ab]	0.83±0.03[c]	1.55±0.07[e]	83.09±0.19[a]
YVA	8.13±0.06[c]	2.95±0.07	2.35±0.07[c]	0.89±0.00[c]	2.05±0.07[c]	83.64±0.14[a]
KRM	8.55±0.44[c]	3.15±0.07[b]	3.05±0.07[b]	1.25±0.01[b]	2.30±0.00[b]	81.71±0.43[b]
PND	10.73±0.24[b]	3.25±0.07[b]	2.25±0.07[c]	0.84±0.01[c]	1.75±0.07[d]	81.19±0.30[b]
GSZ	11.78±0.14[a]	3.45±0.07[a]	3.43±0.19[a]	1.53±0.35[a]	2.55±0.71[a]	77.27±0.30[c]

Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05). **KEY: Sample XWB: 100% maize flour; **Sample YVA:** 95% maize flour and 5% African yam bean; **Sample KRM:** 90% maize flour and 10% African yam bean; **Sample PND:** 85% maize flour and 15% African yam bean: **Sample GSZ:** 80% maize flour and 20% African yam bean*

Mineral Composition of Flour Produced from Maize and African Yam Bean

The Mineral composition of maize and African yam bean composite flour are shown in Table 2. The highest (82.50 mg/100g) calcium content was observed in sample XWB while the lowest value (62.50mg/100g) was recorded in sample KRM. Significant difference (p<0.05) exists among the samples except sample KRM and PND. The highest (25.00 mg/100g) magnesium content was observed in sample XWB while the lowest value (17.50 mg/100g) was recorded in sample KRM. There was no significant difference (p>0.05) among the samples except sample XWB and GSZ respectively. The highest iron content (3.55 mg/100g) was observed in sample YVA while the lowest value (3.05 mg/100g) was recorded in sample KRM and GSZ respectively. There was no significant difference (p>0.05) between sample XWB and PND, YVA and GSZ respectively. The highest sodium content (105.00 mg/100g) was observed in sample XWB while the lowest value (77.50 mg/100g) was recorded in sample KRM. Significant difference (p<0.05) exists among the samples except sample YVA and PND. The highest Zinc content (0.03 mg/100g) was observed in sample YVA and GSZ respectively while the lowest value (0.01mg/100g) was recorded in sample PND. There was no significant difference (p>0.05) among the samples except sample XWB and KRM. The highest phosphorus content (52.50 mg/100g) was observed in sample XWB while the lowest value (37.50 mg/100g) was recorded in sample KRM. Significant difference (p<0.05) exists among the samples except sample YVA and PND. The mineral composition of the flour samples was found to increase with increase in substitution level. The increase in the mineral composition of the samples may be due to the reduction in the antinutrients. It has been reported that antinutrients tie up minerals in food thereby making them unavailable in the food. Hence, the reduction of these antinutrients could be responsible for increase in the mineral composition.

Table 2: Mineral Composition of Flour Produced from Maize and African Yam Bean

SAMPLE	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Sodium (mg/100g)	Zinc (mg/100g)	Phosphorus (mg/100g)
XWB	62.50±3.53[c]	17.50±3.53[b]	3.05±0.07[c]	77.50±3.53[d]	0.02±0.00[ab]	37.50±3.53[c]
YVA	70.00±0.00[bc]	20.00±0.00[ab]	3.55±0.07[a]	85.00±0.00[c]	0.01±0.00[b]	47.50±3.53[ab]
KRM	77.50±3.53[ab]	22.50±3.53[ab]	3.25±0.07[b]	95.00±0.00[b]	0.03±0.00[a]	40.00±0.00[bc]
PND	77.50±3.53[ab]	22.50±3.53[ab]	3.05±0.07[c]	85.00±0.00[c]	0.01±0.00[b]	47.50±3.53[ab]
GSZ	82.50±3.53[a]	25.00±0.00[a]	3.45±0.07[a]	105.00±0.00[a]	0.02±0.00[b]	52.50±3.53[a]

Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05). **KEY: Sample XWB: 100% maize flour; **Sample YVA:** 95% maize flour and 5% African yam bean; **Sample KRM:** 90% maize flour and 10% African yam bean; **Sample PND:** 85% maize flour and 15% African yam bean: **Sample GSZ:** 80% maize flour and 20% African yam bean.*

Proximate Composition of Maize-chip Produced from Maize and African Yam Bean

The proximate composition of Maize-chip produced from maize and African yam beans are shown in Table 3. Proximate analysis included the moisture content, ash content, crude protein content, crude fat content and carbohydrates content. The highest moisture content (15.23%) was observed in sample PND while the lowest value (11.80 %) was recorded in sample GSZ. Moisture content is an indicator of shelf-life stability; an increase in moisture content enhances microbial contamination and chemical reactions that could lead to a reduction in food quality and stability (Ogunlakin *et al.*,2012). This implies that sample PND, YVA and XWB may have a short shelf life due to their high moisture content. The moisture content obtained in this study was relatively higher than the range 1.72-2.13% reported by Idowu, (2015) for *maize-chip* made from maize and African yam bean flour blends and the values are similar to the range 10.45 – 11.05% reported by Abegunde *et al.,* (2014) for maize-chip fortified with cowpea flour. Significant difference (p<0.05) exists among the samples except sample KRM and GSZ.

The highest protein content (1.70 %) was observed in sample GSZ while the lowest value (1.01 %) was recorded in sample XWB. The crude protein was observed to increase with increase in African yam beam flour inclusion in the study. Increase in the protein content could be attributed to high protein contents reported for African yam bean (Eneche, 2005). A similar trend was obtained for production of cakes from wheat and African yam bean composite flour (Idowu, 2015). According to Abegunde *et al.,* (2014) most leguminous plant seeds are rich in nutrients such as digestible protein with good array of amino acids and minerals. The protein content obtained in the study are relatively low compared to the range 7.15-9.45%, 9.91-13.11% and 15.20 – 23.03% reported by Oluwafemi *et al.,* (2018), Idowu, (2015) and Abegunde *et al.,* (2014) respectively. Significant difference (p<0.05) existed among the samples except sample KRM and PND. The highest crude fat content (10.53 %) was observed in sample KRM while the lowest value (7.45 %) was recorded in sample YVA and PND. Fats, especially the unsaturated fat are prone to oxidation and shorten shelf-life of food products (Afoakwa *et al*, 2007). A decrease was observed in the fat content of maize-chip with increased level of African yam bean flour except sample KRM. This makes products from African yam bean desirable since less fat contents implies consumption of less calories which is beneficial from health standpoint as obesity, coronary heart diseases and other illnesses attributed to consumption of too much fat could be minimized. Also, low fat food products are less susceptible to rancidity and hence, more shelf stable. Fat content observed in this study were higher than the values reported by Amanyunose *et al.,* (2021). This could be due to the amount of frying oil added to the snack during the frying process. Fat improves flavour and increases the mouth-feel of foods and it is a significant factor in food formulation (Abioye *et al.,*2016). Significant difference (p<0.05) exists among the samples except sample YVA and PND. The highest crude fiber content (1.82 %) was observed in sample KRM while the lowest value (1.01 %) was recorded in sample YVA. Crude fibre composition is a measure of the quality of indigestible cellulose, pentose, lignin and other components of this type present in food. Crude fibre has little food value but provide bulk necessary for peristaltic action in the intestinal tract (Anderson *et al.,*2009).

The result of the crude fibre obtained for fried Maize-chip in this study was observed to be similar to that obtained by Ayinde *et al.,* (2011), Akoja & Ogunsina, (2018) and Duada *et al.,* (2020) with lower values of 1.45%, (1.90 - 1.67%) and (1.50% - 1.67%) respectively from different legume fortified maize snacks. Oranusi & Dahunsi (2015). Crude fibre aids in digestion and bowel movement and all Maize-chip study samples have the potential of conferring crude fibre properties. Significant difference (p<O.O5) exist among the samples except sample XWB and GSZ. The highest total ash content (2.25 %) was observed in sample GSZ while the lowest value (1.75 %) was recorded in sample YVA. There was no significant difference (p>O.O5) between sample XWB and PND, sample YVA and KRM respectively. Ash content indicates the mineral content of any food sample. It is the residue left after the complete combustion of organic compounds (Usman *et al.,* 2015). According to Ayoola *et al.* (2012). High ash content in food is an indication of high mineral content, although it may also be an indication of impurities in the samples. The ash content of any food material represents the inorganic elements obtained after the combustion of the organic materials in the food and these inorganic materials are composed of mineral element (calcium, magnesium, iron, phosphorus, etc) which are important for building rigid structures and regulatory functioning of the body (Akajiaku *et al.,* 2018). The higher ash content of the snack may be attributed to the presence of some minerals in the AYB flour. This further buttress the nutritional importance of African yam bean.

The highest carbohydrates content (75.91 %) was observed in sample GSZ while the lowest value (72.43 %) was recorded in sample PND. There was significance difference among the samples. There was no significant difference (p>0.05) among the samples except sample GSZ. Total carbohydrate is an indication of organic matter present in the samples and is directly proportional to the dry matter content. The difference in total carbohydrate content among the Maize-chip samples can be attributed to the composition of other nutrients and the effect of processing on the maize-chip. It was observed that the protein, crude fat and crude ash of the maize-chip significantly reduced compared to that of the flour sample. This could be attributed to the processing method (deep frying) the maize-chip was subjected to which could aid loss of essential nutrient.

Mineral Composition of Maize-chip Produced from Maize and African Yam Bean

The mineral composition maize-chip produced from maize and African yam bean composite flour are shown in Table 4. Most of these minerals have a vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production as well as regulation of cardiac and skeletal muscle activities (Tunde *et al.,* 2013). The highest calcium content (62.50 mg/100g) was observed in sample GSZ while the lowest value (45.50 mg/100g) was recorded in sample YVA. Calcium is an important component of intracellular processes that occur within insulin responsive tissues like skeletal muscle and adipose tissue (Hassan *et al.,*2018). There was no significant difference (p>0.05) among the samples. The magnesium content ranged from 10.00– 17.50 mg/100g.

Table 3: Proximate Composition of Maize-chip Produced from Maize and African Yam Bean

SAMPLE	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Total Ash (%)	Carbohydrate (%)
XWB	13.35±0.71[c]	1.01±0.00[d]	8.73±0.03[b]	1.15±0.07[bc]	1.95±0.07[ab]	73.82±0.25[b]
YVA	14.17±0.24[b]	1.15±0.07[c]	7.45±0.06[c]	1.01±0.08[c]	1.75±0.07[b]	74.48±0.22[b]
KRM	11.95±0.12[d]	1.45±0.07[b]	10.53±0.03[a]	1.82±0.03[a]	1.80±0.14[b]	72.46±0.16[b]
PND	15.23±0.32[a]	1.55±0.07[b]	7.45±0.07[c]	1.25±0.07[b]	2.10±0.14[ab]	72.43±0.67[b]
GSZ	11.80±0.28[d]	1.70±0.00[a]	8.16±0.07[d]	1.18±0.10[bc]	2.25±0.21[a]	75.91±0.10 [a]

Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05).* ***KEY: Sample XWB:* *100% maize flour;* ***Sample YVA:*** *95% maize flour and 5% African yam bean;* ***Sample KRM:*** *90% maize flour and 10% African yam bean;* ***Sample PND:*** *85% maize flour and 15% African yam bean:* ***Sample GSZ:*** *80% maize flour and 20% African yam bean*

The highest magnesium content was observed in sample XWB while the lowest value was recorded in sample KRM. Magnesium has been reported as important bone health, needed as a cofactor for numerous reactions in the body. Significant difference (p<0.05) exists among the samples except sample YVA and PND. The highest iron content (2.95 mg/100g) was observed in sample KRM while the lowest value (2.65 mg/100g) was recorded in sample PND and XWB respectively. Iron is an essential component of hemoglobin and it is critical to the proper functioning of the immune system and the production of energy (Chen *et al.*,2010). Significant difference (p<0.05) exists among the samples except sample KRM and GSZ. The highest sodium content (97.50 mg/100g) was observed in sample XWB while the lowest value (67.50 mg/100g) was recorded in sample KRM.

The highest zinc content (0.02 mg/100g) was observed in sample GSZ while the lowest value (0.00 mg/100g) was recorded in sample YVA, PND and XWB respectively. Zinc plays a key role in the regulation of insulin production by pancreatic tissues and glucose utilization by muscles and fat cells (Eleazu *et al.*,2013). There was no significant difference (p>0.05) among the samples. The highest phosphorus content (42.50 mg/100g) was observed in sample XWB while the lowest value (25.00 mg/100g) was recorded in sample KRM. Phosphorus also participated in several biological processes which include bone mineralization, energy production, cell signaling and regulation of acid-base homeostasis. Lack of phosphorus will therefore result in impaired bone mineralization, reduced bone strength and poor growth (Eleazu *et al.*,2015). There was no significant difference (p>0.05) among the samples except sample XWB and CAB. The mineral composition of the sample showed that sodium was the predominant mineral, followed by calcium and phosphorus. Other elements were found in comparatively low concentrations. Higher mineral contents were found in maize-chip samples containing higher quantity of African yam bean flour.

Table 4: Mineral Composition of Maize-chip Produced from Maize and African Yam Bean Composite Flour

SAMPLE	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Sodium (mg/100g)	Zinc (mg/100g)	Phosphorus (mg/100g)
XWB	47.50±3.53[b]	10.00±0.00[c]	2.65±0.07[c]	67.50±3.53[c]	0.01±0.00[a]	25.00±7.07[b]
YVA	45.00±0.00[b]	12.50±3.53[bc]	2.85±0.07[ab]	72.50±3.53[bc]	0.00±0.00[a]	37.50±3.53[a]
KRM	57.50±3.53[a]	20.00±0.00[a]	2.95±0.07[a]	77.50±3.53[b]	0.00±0.00[a]	37.50±3.53[a]
PND	62.50±3.53[a]	12.50±3.53[bc]	2.75±0.07[bc]	92.50±3.53[a]	0.02±0.03[a]	32.50±3.53[ab]
GSZ	57.50±3.53[a]	17.50±3.53[b]	2.95±0.07[a]	97.50±3.53[a]	0.00±0.00[a]	42.50±3.53[a]

Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05).* ***KEY: Sample XWB:* *100% maize flour;* ***Sample YVA:*** *95% maize flour and 5% African yam bean;* ***Sample KRM:*** *90% maize flour and 10% African yam bean;* ***Sample PND:*** *85% maize flour and 15% African yam bean:* ***Sample GSZ:*** *80% maize flour and 20% African yam bean.*

Sensory Evaluation of Maize-chip Produced from Maize and African Yam Bean

The sensory evaluation of maize-chip produced from maize and African yam beans are shown in Table 5. The highest colour (7.80) attribute was observed in sample KRM while the lowest value (5.00) was recorded in sample PND. There was no significant difference (p>0.05) exist among the samples except PND. The crunchiness attribute ranged from 4.50 – 7.80. The highest taste (7.60) attribute was observed in sample KRM while the lowest value (5.00) was recorded in sample PND. The highest aroma content (7.00) was observed in sample YVA while the lowest value (4.80) was recorded in sample PND. There was no significant difference (p>0.05) between sample YVA and KRM, sample GSZ and XWB. The highest appearance value (8.00) was observed in sample KRM while the lowest value (6.00) was recorded in sample PND. Significant difference ($p<0.05$) exists among the samples except PND and KRM. There was no significant difference ($p>0.05$) between sample YVA and KRM, sample GSZ and XWB. The highest overall acceptability (8.20) was observed in sample KRM while the lowest value (6.20) was recorded in sample PND. There was no significant difference ($p>0.05$) between sample KRM and XWB, sample YVA and GSZ. The results for taste, texture and flavour show similar score trend. Sample PND had the least scores for taste (5.00) and had the least value for aroma (4.80), while sample KRM had the highest scores for mostly all the sensory parameters. Sample KRM was the most preferred in terms of overall acceptability among the composite maize-chip which compared favorably with the control sample (6.04).

Table 5: Sensory Evaluation of Maize-chip Produced from Maize and African Yam Bean

Sample	Colour	Crunchiness	Taste	Aroma	Appearance	Overall Acceptability
XWB	7.60±1.14^{a}	7.80±1.30^{a}	7.00±1.22^{ab}	6.60±1.81^{ab}	6.80±1.09^{ab}	7.80±1.30^{a}
YVA	6.80±1.09^{a}	6.80±1.92^{a}	6.20±1.09^{ab}	7.00±1.22^{a}	7.40±0.89^{ab}	7.20±1.48^{ab}
KRM	7.80±0.83^{a}	6.80±0.44^{a}	7.60±1.67^{e}	6.80±0.44^{a}	8.00±0.00^{a}	8.20±0.83^{a}
PND	5.00±1.00^{b}	4.50±0.89^{b}	5.00±2.23^{b}	4.80±1.30^{b}	6.00±2.00^{b}	6.20±1.09^{b}
GSZ	7.40±1.14^{a}	7.20±1.64^{a}	6.80±1.30^{ab}	6.20±1.48^{ab}	7.00±0.70^{ab}	7.40±0.54^{ab}

Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05).* ***KEY: Sample XWB:* *100% maize flour;* ***Sample YVA:*** *95% maize flour and 5% African yam bean;* ***Sample KRM:*** *90% maize flour and 10% African yam bean;* ***Sample PND:*** *85% maize flour and 15% African yam bean:* ***Sample GSZ:*** *80% maize flour and 20% African yam bean*

CONCLUSION AND RECOMMENDATION

The study showed that low nutritional quality of 'maize-chip' can be improved through the addition of African yam bean. This is reflected in the improved nutrition which increased with increase African yam bean flour inclusions level. The substitution of maize with African yam significantly improved the mineral and functional properties of the blends. Sensory evaluation showed that consumers tend to prefer *maize-chip* from 90:10 maize and African yam bean composite flour. However, it may be due to familiarity with *maize-chip* made solely from maize. If the policy to add African yam bean is introduced, there will be an increase in demand and utilization for African yam bean. Hence this would eventually encourage the cultivation of more hectares by the farmers for the crop and more income on returns. Substitution of African yam bean to maize 10% is therefore recommended for production of snacks which will give a product with high nutritional value and quality fiber.

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Author's Contributions

ATA, IGE & BOT managed data collection, interpretation of data, writing of manuscript, material support, and review of manuscripts and wrote the first draft of the manuscript. ATA, IGE & ARB managed the literature searches. FJF, OAO & IGE managed the development of methodology, data analysis, and the development of the model. All authors read and approved the final manuscript.

Ethical Statement

Not applicable

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