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Development and Quality Evaluation of Flour and Enriched Chin – Chin Snacks from Flour Blends of Maize (*Zea mays*), Soybean (*Glycine max*) and Groundnut (*Arachis hypogea*)

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ABSTRACT
Flour samples prepared from maize, soybean and groundnut and their blends were evaluated for their functional and nutrient composition. From the results obtained, flour blends with higher quality parameters were selected and used to develop formulations for the production of chin-chin snacks while chin-chin from 100% maize flour served as control. Physicochemical analyses were examined on the flour blends and chi-chin, while sensory acceptance of the chin-chin was conducted using 20-member panellists. Results were presented as mean ± standard deviation of duplicate determinations, while level of significance was accepted for $p \leq 0.05$. The result of the functional properties of the flours and their blends showed that the bulk density ranged from 0.71 to1.82 g/ml. The water absorption capacity and oil absorption capacity of the flours ranged from 1.49 to 2.81 % and 1.10 to 2.52 % respectively. Foam stability ranged from 15.11 - 87.58 %. The emulsion stability of the flours ranged from 10.00 to 49.28 %. While gelatinization temperature ranged from 38.08 – 96.70°C. The selected composite flours were also nutrient rich in protein (16.39 - 20.33 %), vitamin A (794.50 - 902.50 mg RE/100g) and minerals. The evaluation results of the chin-chin supplemented with soy-groundnut showed significant decrease in moisture content (5.4-9.64 %), increase in protein (18.55 to 26.44 %), fat (10.97 to 20.54 %), calcium (12.03 to 19.01 %).There were decrease in carbohydrate (55.71 to 31.54 %) magnesium (154.72 to 82.89 mg/100g) and vitamin B_1 (3.05 to 2.77 mg/100g) contents when compared to the control sample 101 (100% maize flour). The sensory evaluation showed that acceptable chin-chin products were produced from blends of maize; soybean and groundnut flour. However, the chin-chin products differed was significantly with respect to general acceptability.
Keywords: Maize, soya bean, groundnut, snack, proximate, mineral, vitamin, sensory

INTRODUCTION

Protein energy malnutrition (PEM) is one of the major nutritional dilemma in developing countries (Offia-Olua, 2014)as cereals, are the staple diet of most under developed countries (Eke-Ejiofor and Mbaka, 2018).The snacks commonly made from cereals are deficient in major nutrients needed for proper growth and development (Odro-Obeng and Plahar, 2017).

Chin-chin is a fried snack popular in West Africa. It is similar to the Scandinavian snack Wenart; crunchy donut-like, baked or fried dough usually made from wheat flour and other customary baking ingredients (Adegunwa *et al*., 2014). The dough is usually kneaded and cut into small squares before frying. It can be either hard or crunchy. It is one of the most desirable snacks for both youth and elderly people due to their low production cost, convenience, long shelf-life and ability to serve as a vehicle for important nutrients (Akubor, 2007).

Soybeans and groundnuts are highly digestible sources of amino acids and economic alternative to traditional meat proteins, which can be added to foods without jeopardizing the flavor characteristics (Leonora *et al*., 2008). Complementing cereals and

legumes have been reported to make up for the deficiencies of lysine and methionine which are essential amino-acids required for a balanced meal (Aremu *et al*., 2007). The utilization of pulses and legumes to supplement cereal can be an effective approach to combat protein energy malnutrition (PEM), diabetes and other deficiency diseases (Bahadoran and Mirmiran, 2015). They could also offer more options in the production of gluten-free baked products which will be beneficial to those with gluten intolerant condition, thereby reducing cases of celiac diseases (Ndife, 2016).

Although, previous research have been made on the production of chin-chin from cereals (Adegunwa *et al*., 2014; Oduro-Obeng and Plahar, 2017), but a study is yet to be conducted on developing energy-dense and nutrient rich chin-chin from flour blends of maize and other high protein legumes such as soybean and groundnut. The main objective of this project was to produce and evaluate composite flours from cereal and legume sources that will be used to produce nutritive and acceptable whole meal and gluten free ready-to eat Chin-chin snacks.

MATERIALS AND METHODS

Sample collection

The raw materials: maize grain (*Zea mays*), soybean (*Glycine max*), and groundnut (*Arachis hypogaea)* and other baking ingredients were purchased at Ubani market Umuahia, Abia State. The reagents and facilities used for the study were of analytical grade and requisite standard. The analyses were carried out at National Root Crop Research Institute, Umuahia, Nigeria.

Processing of Flours

The maize flour was prepared by sorting the maize grain, it was then roasted for 15 minutes, allowed to cool, and hammer milled (9FC-360A JinJuhong machinery, China). Similarly the soybean flour was prepared by sorting and cleaning the soybeans, and roasted for 15 minutes, allowed to cool. It was winnowed and milled before sieving (0.4 µm) to flour. Groundnut was prepared using the following steps: sorting, roasting for 30 minutes, cooling, dehulling and winnowing, then milled ((9FC-360A JinJuhong machinery, China) and sieved using 0.4µm mesh. Composite flours were formulated by mixing the three different flour samples at different ratios Table1.

Formulation of Composite flours

The maize, soybean and groundnut flours produced were formulated into composites to improve the nutritional composition of the chin-chin using the proportions shown on Table 1. The plain maize (A), soybean (B) and ground nut (C) flours (100%) served as basis for comparison. All the flours were analysed for their functional properties, proximate, mineral and vitamin compositions.

Table 1: Formulation for composite flours (%)

Sample	Maize flour (%)	Soybean flour (%)	Groundnut flour (%)	Total
MAF	100	0	0	100
SBF	0	100	0	100
GNF	0	0	100	100
MSF	50	50	0	100
MGF	50	0	50	100
MSG1	50	25	25	100
MSG2	50	10	40	100
MSG3	50	40	10	100
MSG4	33.33	33.33	33.33	100

Where: **MAF** = 100% maize, **SBF** = 100% soybean, **GNF** = 100% groundnut, **MSF** = 50% maize and soybean, **MGF** = 50% maize and groundnut, **MSG1** = 50% maize, 25% each soybean and groundnut, **MSG2** = 50% maize, 10% soybean and 40% groundnut, **MSG3** = 50% maize, 40% soybean and 10% groundnut, **MSG4** = 33.33% each maize, soybean and groundnut

Production of Chin-chin

Owing to their high nutrient values as evaluated, chin-chin snacks were subsequently produced from 100% maize flour (101), 33.3% each of maize flour, soybean flour and groundnut flour (sample code 102), 50% maize flour, 10% soybean flour and 40% groundnut flour (sample code 103), and sample 104 containing 50% maize, 40% soybean and 10% groundnut flours. The method of Adegunwa *et al*. (2014) with slight modifications was adopted for the chin-chin production. One hundred grams of the blended flour was put in a bowl followed by the addition of 2g of salt and 0.5 g of ground nutmeg. After this, 12 g of margarine was mixed together with it evenly. Sugar (20 g) and 65ml of water were added and the mixture was thoroughly mixed and kneaded to make fairly stiff dough. The thick dough was rolled tightly on a board and cut into cubes of 4 cm each. This was followed by deep frying in hot oil until golden brown was observed. The chin-chin was allowed to drain off oil, cool and packaged in high density polyethylene bags for storage until the chin-chins were evaluated.

Determination of functional properties

The density, water and oil absorption capacities, foaming and emulsion stability and gelation temperature of the flour samples were determined (Onwuka, 2018).

Bulk density

Ten (10 ml) millilitres capacity graduated measuring cylinder was weighed and the samples gently introduced into it. The bottom of cylinder was gently tapped several times until there was no further diminution of the sample level after filling to the 10 ml mark. The bulk density was calculated as: Bulk density (g/ml) = weight of sample (g) / volume of sample (ml).

Oil and Water absorption capacities

One gram of sample was weighed into a graduated centrifuge tube; 10 ml of water or oil was added and thoroughly mixed using a warring blender (Kenwood) for 30 sec. The sample was allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000 rpm for 30 minutes. The volume of free water or oil (supernatant) was read directly from the graduated

centrifuge tube. Absorption capacity was expressed as grams of oil or water absorbed (or retained) per gram of sample.
Calculation: The amount of oil or water absorbed (total minus free) was multiplied by its density for conversion to grams.

Foam stability

After the determination of foaming capacity, the foam volume was recorded at 15, 30, 60 and 120 after whipping to determine the foam stability

$$\text{Foam stability} = \frac{\text{foam volume after time } t}{\text{Initial foam volume}}$$

Emulsification stability

Emulsion stability was estimated after heating the emulsion contained in calibrated centrifuge tube at 80 ^{o}C for 30 min in a water bath, cooling for 15 min under running tap water and centrifuged at 2000 rpm for 15 min. the emulsion stability expressed as percentage was calculated as the ratio of the height of emulsified layer to the total height of the mixture

Gelatinization temperature

Ten per cent (10 %) suspension of the flour sample was prepared in a test tube and was heated in a boiling bath with continuous stirring. Temperature of the sample was recorded with a thermometer 30 sec after gelatinization was visually noticed as the Gelatinization temperature.

Proximate analysis

The procedures of (Onwuka, 2018) were used in the determination of the proximate composition: moisture, protein, lipid, fibre and ash. The carbohydrate contents were determined by recommended mathematical procedures.

Determination of total ash content

This was done using the furnace incineration gravimetric method. A measured weight (five grams) of each sample was placed in a previously weighed porcelain crucible. The sample in crucible was put in muffle furnace set at 550 ^{o}C and allowed to burn for 3 hr. (until the sample became a grey ash. The sample in crucible was very carefully removed from the furnace (taking care not to allow air to blow away the ash), and cooled in a desiccator. It was reweighed by difference; the weight of ash was obtained in percentage. It was given by the formula;

% Ash= W_2- W_1/weight of sample × 100/1

Where; W_1= weight of crucible + sample and W_2 = weight of empty crucible

Determination of moisture content

A measured weight of each sample (5 g) was placed in a weighed moisture can. The can and its content were dried in the oven at 105 ^{o}C for three hours in the first instance. It was cooled in a desiccator and reweighed. The weight was recorded, while the sample was returned to the oven for further drying. The drying, cooling and weighing were continued repeatedly until a constant weight was obtained. The weight of moisture loss was determined by difference and expressed as a percentage.

Thus, % moisture= W_2- W_3/ W_2 - W_1×100/1

Where W_1=weight of empty can, W_2=weight of can before drying and W_3=weight of can + sample after drying to a constant weight.

Determination of fat content

The fat content of flour samples were determined by the continuous solvent extraction method using a soxhlet apparatus.

Five grams of each sample was wrapped in a Whitman filter paper No 1. The wrapped sample was put into a soxhlet reflux flask containing two hundred millilitres (200 ml) of petroleum ether. The upper end of the reflux flask was connected to a condenser. By heating the solvent in the flask through electro-thermal heater, this vaporized and condensed into the reflux flask. Soon the wrapped samples were completely immersed in the solvent and remained in contact with it until the flask was filled up and siphoned over, thus carrying oil extract from the sample down to the boiling flask. This process was allowed on repeatedly for about four hours before the defatted sample was removed and reserved for crude fibre analysis. The solvent was recovered and the extracting flask and its content were dried in the oven at 60 ^{o}C for three minutes. After cooling in a desiccator, the flask was reweighed and the weight of fat (oil) extracted was calculated as:

% fat= W_2- W_1/weight of sample × 100/1

Where W_1=weight of empty extracting flask, W_2=weight of flask and oil extract

Determination of crude fibre content

Five grams of each sample was boiled in two hundred millilitres of 1.25 % sulphuric acid solution for thirty minutes under reflux. The boiled sample was held in muslin cloth to trap the particles. It was returned to the flask and boiled again in twenty millilitres of 1.25 % sodium hydroxide for another thirty minutes under the same condition. After washing in several portions of hot water, the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105 ^oC for three hours after cooling in a dessicator, then reweighed and put in a muffle furnace and incinerated at 550 ^oC for two hours (until they become ash). The crucibles were cooled in a desiccator and weighed.

The crude fibre (CF) content was calculated as:

% CF= W_2- W_3/weight of sample × 100/1

Where; W_2=weight of crucible + sample after washing and drying, and W_3=weight of crucible+ sample as ash.

Determination of crude protein content

This was done by the Kjeldahl method. The total nitrogen was determined and multiplied with factor a 6.25 to obtain the protein value. Half gram (0.5 g) of each sample was mixed with ten millilitres of concentrated sulphuric acid (H_2SO_4) of analytical reagent grade in a Kjeldahl digestion flask. A tablespoonful of Kjeldahl catalyst was added to it and the mixture was digested (heated under a fume cupboard until a clear solution was obtained). The acid and other reagents were digested but without sample to form the blank. The entire digest were carefully transferred to one hundred millilitres volumetric flask using distilled water to make up to 100 ml mark in the flask. Ten millilitres (10 ml) portion of each digest was mixed with equal volume of 40% sodium hydroxide solution in the Kjeldahl distillation unit. The mixture was distilled and the distillate collected into ten millilitres of 4% boric acid solution containing three drops of mixed indicator (Bromocresol green and methyl red). A total of 50-75 ml distillate was obtained and titrated against 0.01 M HCl acid solution. Titration was done from the initial green colour until a bright pink colour was observed.

The nitrogen content was calculated as:

% N_2= 100 / W × N × 14 / 100 × VF / B) T

Where; W = weight of sample analysed, N = normality of acid, VF = total volume of digested distillate, T = titre value and B = blank titre value.

Determination of carbohydrates

The carbohydrate content was calculated by difference as the Nitrogen Free extraction (NFE).

The NFE is given as;

%NFE=100-% [a + b + c + d + e]

Where a-e = % crude protein, % crude fibre, % moisture, % crude fat and % ash respectively.

Mineral assay

Mineral content of the sample was done following the dry ash extraction method (AOAC, 2005), James (1995) and Kirk and Sawyer (1998).

A measured weight of the sample was burnt to ashes (as in ash determination) thereby removing all the organic materials leaving the inorganic ash. The resulting ash was dissolved in 5mls of dilute (0.1 m) HCl solution and then diluted to 100mls in a volume flask. This extracts was used in specific analysis for the different mineral elements.

Determination of Potassium by Flame Photometry

The instrument, Jaway digital flame photometer, was setup according to the manufactures instruction. It was switched on and allowed about 10 to 15 minutes to equilibrate. Meanwhile standard potassium solution were prepared and diluted in series to contain 10, 8, 6, 4, and 2 ppm of K.

After calibrating the instrument, 1ml of each standard was aspirated into it and sprayed over the non-luminous flame. The optical density of the resulting emission from standard solution was recorded. Before flaming, the appropriate element fitter (K) was put in place with the standards measured, the test sample extracts were measured in time and they were plotted into standard curve which was used to extrapolate the content of each test element and calculated as shown below:

$$K\left({}^{mg}/_{100g}\right) = \frac{X}{1000} \times \frac{Vf}{Va} \times DX \times \frac{100}{W}$$

Where X is the concentration of the test element from the curve.

Determination of Phosphorus

Phosphorus in the test sample was determined by the molybdo vanadate colorimetric method James (1995); Kirk and Sawyer (1998). A measured volume of the dry ash (2mg) digest of the samples was dispersed into a 50 ml volume flask. At the same time, equal volumes of distilled water and standard phosphors solutions were measured into different flask to serve as reagent blank and standard respectively. 2mls of the phosphorus colour reagent (molybdo vanadate solution) was added to each of the, flask and allowed to stand at room temperature for 15 minutes. Content of each flask was diluted to the 50ml mark with distilled water and its absorbance was measured in a spectrophotometer at a wavelength of 540 nm with the reagent blank at zero. The phosphorus content was calculated using the formula below:

$$P\ (mg/100g) = \frac{100}{W} \times \frac{au}{as} \times C \times \frac{Vt}{Va}$$

Where W = Weight of sample ashes
Au = Absorbance of test sample
As = Absorbance of standard phosphorus solution.
C = Concentration of standard phosphorus solution
Vt= Total extract volume
Va= Volume of extract analyzed

Determination of Calcium and Magnesium by Complexiometric Titration

The versanate EDTA titrimetric method was employed James (1995); Nwosu *et al.* (2014). 20 ml portion of the extract was dispersed into conical flask and treated with pinches of the masking agents (hydroxyl amine hydrochloride, sodium cyanide and sodium potassium ferrocyanide) and was allowed to dissolve, after which 20 mls of ammonia buffer was added to raise the pH to 10.00 (a point at which both calcium and magnesium form complexes with EDTA). The mixture was titrated against 0.02N EDTA solution using eriochrome 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 Ca^{2+} alone in the test samples. Titration of calcium alone was done in similarity with the above titration however, 10% of NaOH was used in place of the ammonia buffer and solechrome Dark blue indicator in place of Eriochrome Black T. from the titre value obtained, the Ca^{2+} and mg^{2+} content were calculated as shown below:

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

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)

Determination of Zinc and Iron

The method of AOAC (1995) was used 2g of each sample was collected and. was added into HCL for preparation of stock solution. Aliquot of the diluted clear digest was used for spectrophotometric reading. A standard solution of the different elements was prepared in concentration of 0.0, 0.5, 1.0 and 1.5ppm.

Calculations

$$Zn(^{mg}/_{1000}) = \frac{100}{W} \times \frac{X}{10^3} \times \frac{Vf}{Va}$$

$$Fe(^{mg}/_{1000}) = \frac{100}{W} \times \frac{X}{10^3} \times \frac{Vf}{Va}$$

X = Ppm off curve

W = Weight of sample used

Vf = Volume of total sample

Va =Volume of sample solution used

Vitamin assay

The ascorbic acid (vitamin- C), B-carotene (vitamin -A), thiamine (vitamin B_1), riboflavin (vitamin-B_2) and niacin (vitamin-B_3) contents of the samples were determined by the method described by Nielsen (2003) with some modifications using UV-VIS spectrophotometer.

Sensory evaluation

The protocol described by Iwe (2010) was used. The organoleptic properties of chin-chin snacks were evaluated by 20-member semi-trained panellists, randomly selected from the staff and students of the university. Quality attributes such as appearance, aroma, texture, taste and general acceptability of the products were scored with a 9-point hedonic scale. In the questionnaire, the panellists were required to observe and taste each coded sample and grade them on a 9-point Hedonic scale which ranged from like extremely for 1 to dislike extremely for 9, with 5 as neither like nor dislike

Experimental Design and Statistical Analysis

The experimental set-up was of a completely randomized design. The data obtained from the various analyses were subjected to analysis of variances using the statistical package for social sciences (SPSS), version 16.0. Results are presented as mean ± standard deviations of triplicate determinations. One way analysis of variance (ANOVA) was used for comparison of the means. Differences between means were considered to be significant at $p<0.05$ using the Duncan multiple range test.

RESULTS AND DISCUSSION

Functional Properties of Flours samples

The result of the functional properties of maize, soybean and groundnut flour blends is presented in Table 2. The functional properties of flour play an important role in the manufacturing of products as it determine the application and use of food materials for various food products (Adeleke and Odedeji, 2010, Onwuka, 2018).

The bulk densities of the flours ranged from 0.73 to 1.82 g/ml. The high bulk density 1.82 g/ml obtained for sample SBF (100% soybean) and 0.81 g/ml sample MSG1 (50% maize and 25% each of soybean and groundnut flours) suggest stability for use in food preparations. Bulk density is an indication of the porosity of a product which influences the flour wet ability and packaging design (Iwe and Onalope, 2009). The Bulk density depends on the particle size and initial moisture content of flours (Ali *et al*., 2012). The ability of protein in flours to physically bind water is a determinant of its water absorption capacity (Ijarotimi *et al*., 2013).

The water absorption capacity of the flours ranged from 2.11 to 1.49 %. The water absorption was highest in 100% soybean flour (2.81 %) and lowest in 100% maize flour (1.49 %). The water absorption capacity improved with increased soybean and groundnut addition in the composite flours. This could be attributed to water affinity of these flours, and their ability to absorb water. The high water absorption capacity flours also have high hydrophilic constituents which may prove useful in baked products where good viscosity is required (Leonora *et al*., 2008)

The oil absorption capacity of the flours ranged between 1.10 to 2.52 %. The highest value was observed in 100% groundnut flour (2.52 %) and the lowest in 100% maize flour (1.10 %). There was significant ($p<0.05$) difference in the OAC of the flours. Higher oil absorption capacity suggest better mouth feel and flavour retention particularly in bakery products where fat absorption is desired (Aremu *et al*., 2007). Oil absorption capacity is an important parameter of flour used in baking (Ikpeme *et al*., 2010), as it also reflects the lipophilic and emulsifying characteristics of the flours (Ali *et al*., 2012).

The foam stability and emulsion stability varied from 15.11 (100% groundnut flour) to 87.58 % (100% soybean flour) and 10.00% (100% groundnut flour) to 52.39% (soybean flour) respectively. Ali *et al*. (2012) reported that the foaming and emulsion stabilities of pearl millet flour improved after addition of soybean flour. Gelatinization of the flours ranged from 38.08 ^{o}C (33.33% maize, soybean and groundnut flours) to 96.70 ^{o}C (100% groundnut flour) which is an indication of their different starch composition. The ability of the gel structure to provide a matrix to hold water, oil, flavour and other food additives in the product is very important (Suri and Tanumihardjo, 2016). Ali *et al*. (2012) reported that gelatinization temperature depend on the starch content of the flour. Gelatinization temperature is the temperature at which gelatinization of starch takes place (Onwuka, 2014).

Table 2: Functional properties of flours

Sample	BD (g/ml)	WAC (%)	OAC (%)	FS (%)	ES (%)	G-Tem (^{0}C)
MAF	$0.71^{b}\pm0.03$	$1.49^{c}\pm0.07$	$1.10^{c}\pm0.06$	$60.8^{c}\pm0.16$	$40.31^{b}\pm0.16$	$79.20^{bc}\pm0.25$
SBF	$1.82^{b}\pm0.05$	$2.81^{a}\pm0.08$	$1.62^{bc}\pm0.07$	$87.58^{a}\pm0.10$	$52.39^{a}\pm0.18$	$66.76^{d}\pm0.18$
GNF	$0.78^{b}\pm0.03$	$2.75^{a}\pm0.04$	$2.52^{a}\pm0.06$	$15.11^{e}\pm0.14$	$10.00^{e}\pm0.23$	$96.70^{a}\pm0.15$
MSF	$0.94^{b}\pm0.04$	$2.48^{b}\pm0.08$	$1.31^{c}\pm0.07$	$70.33^{b}\pm0.13$	$49.28^{a}\pm0.21$	$87.53^{b}\pm0.20$
MGF	$0.73^{c}\pm0.05$	$2.41^{b}\pm0.06$	$1.83^{a}\pm0.05$	$38.75^{d}\pm0.14$	$31.55^{c}\pm0.16$	$74.22^{c}\pm0.25$
MSG1	$0.81^{b}\pm0.04$	$2.65^{a}\pm0.05$	$1.87^{ab}\pm0.04$	$64.2^{c}\pm0.10$	$36.46^{c}\pm0.18$	$71.45^{c}\pm0.18$
MSG2	$0.73^{c}\pm0.03$	$2.11^{b}\pm0.07$	$1.46^{c}\pm0.06$	$71.33^{b}\pm0.12$	$39.17^{b}\pm0.25$	$73.02^{c}\pm0.18$
MSG3	$1.24^{ab}\pm0.04$	$2.07^{b}\pm0.06$	$1.94^{a}\pm0.07$	$18.95_{e}\pm0.13$	$24.82^{d}\pm0.20$	$79.66^{bc}\pm0.22$
MSG4	$1.29^{ab}\pm0.05$	$2.24^{b}\pm0.08$	$2.19^{b}\pm0.06$	$22.42^{d}\pm0.16$	$27.01^{cd}\pm0.18$	$38.08^{e}\pm0.18$

Values are means ± standard deviation; Superscripts within the same columns are significantly different ($p<0.05$)

Where: **BD**: Bulk Density, **WAC**: Water Absorption Capacity, **OAC**: Oil Absorption Capacity, **FS:** Foam stability, **ES**: Emulsion stability, **G-Tem**: Gelation Temperature
MAF = 100% maize, SBF = 100% soybean, **GNF** = 100% groundnut, **MSF** = 50% maize and soybean,
MGF = 50% maize and groundnut, **MSG1** = 50% maize, 25% each soybean and groundnut
MSG2 = 50% maize, 10% soybean and 40% groundnut, **MSG3** = 50% maize, 40% soybean and 10% groundnut
MSG4 = 33.33% each maize, soybean and groundnut

Proximate Composition of flour and Chin-chin samples

The nutrient contents of the both the flours and chin-chin snacks are presented in Tables 3 and 4.

The moisture content of the flour samples ranges from 6.28% to 9.05 %. There were significant differences ($p<0.05$) among the flour samples.

Values obtained for moisture content of chin-chin ranged from 5.45% (chin-chin made from 50% maize, 40% soybean and 10% groundnut flours) to 11.96% (chin-chin from 100% maize flour).Values obtained in this study were comparable to value of 11.5 to 16.51 % reported for infant complementary food made from soybean and cocoyam starch flour by Ojinnaka *et al*. (2013). Low moisture content is desirable, for better shelf stability (Onwuka, 2014). Low moisture content implies high dry matter content of the flours, hence longer shelf-life for such products (Oduro-Obeng and Plahar, 2017), while, low moisture content obtained in this work could be attributed to the effect of composite flour technology, also the processing method (frying) for the chin-chin.

The protein content of the flour samples (9.07% to 28.42%) were significantly different ($p<0.05$). Protein content of the flour samples was observed to be highest in 100% soybean flour (28.42%), while the least value was observed in 100% maize flour (9.07%). 100% soybean flour had the highest value due to the high protein content of the soybean and this could be corroborated with the findings of Oduro-Obeng and Plahar (2017) and Taghdir *et al.* (2017).

The protein content of the chin-chin ranged from 9.04% (chin-chin from 100% maize flour) to 26.44% (chin-chin from 50% maize, 40% soybean and 10% groundnut flours).There was significant ($p<0.05$) difference in the protein levels of the chin-chin. 100% Maize flour chin-chin had the lowest, which reveal that maize flour (cereal) is low in protein content compared to soybean and groundnut (legumes). An increase in protein contents were observed for chin-chin samples with soy and groundnut flours inclusion. This observation agrees with report of Ojinnaka *et al*. (2013) on the addition of soybean and bambara groundnut flour, respectively to complementary foods. The grain-legume combinations used in chin-chin production could help alleviate the problem of protein malnutrition among vulnerable groups (Wardlaw, 2004, Adegunwa *et al*., 2014).

There was significant ($p<0.05$) difference in the crude fibre content of the flour samples with the range of 2.15 - 5.13 %. Flour from 50% maize and soybean had the highest value (5.13 %) while 100% maize had the least (2.15%). Similar trend was also observed in the fibre content of the chin-chin samples.

Chin-chin from 50% maize, 40% soybean and 10% groundnut flours had the highest fibre value of 2.68% while 100% maize flour chin-chin recorded lowest value of 1.22%. The high fibre content could be attributed to the addition of both maize and soybean flours. Diet low in crude fibre is undesirable and may cause constipation and diseases associated with colon (Serrem *et al*., 2011, Ndife *et al*., 2011).

The lipid values of the flours ranged from 2.06 to 36.83%. The lipid content of the sample flours increased with the proportion of legume flours for 100% soybean flour (20.64%) and 100% groundnut flour (36.83%). Same trend was reported by Taghdir *et al.* (2017) on soy gluten free flours. The inclusion of soybean and groundnut flours increased lipid content. Fat content of the chin-chin was highest for product made from 50% maize, 40% soybean and 10% groundnut flours (30.54%), while it was lowest in chin-chin made from 100% maize flour (1.44%). There was significant ($p>0.05$) difference in the fat content of the products. However, it was observed that composite technology improved fat content of the product. Lipids are principal source of energy but must be consumed with caution to avoid obesity and other related diseases. According to Ndife *et al.* (2011), fats improve flavour and increase the mouth feel of food and therefore, are a significant factor in food formulations however with the possibility of rancidity.

The ash content of the flour blends ranged from 1.44 to 3.58%. Flour from 50% maize and soybean the highest value. There was significant difference ($p>0.05$) among the samples. The ash content of samples is an indication of the level of inorganic elements in the flours.

Ash content of chin-chin samples ranged from 1.55 to 3.35%. Chin-chin from 100% maize (control sample) had the lowest ash value of 1.55%. Ash content of the samples was observed to increase with increase in legume flour inclusion. High ash content in the sample would imply high mineral content and its nutritional benefits (Ndife *et al.*, 2011).

The carbohydrate mean value was observed to decrease with increase in soybean and groundnut flours inclusion. Carbohydrate content of chin-chin ranged from 31.54% (chin-chin from 50% maize, 40% soybean and 10% groundnut flours) to 74.79% (100% maize chin-chin). Ndife *et al.* (2011) also reported decreased carbohydrate content of composite flours with legume substitution. High carbohydrate content of thee chin-chin is an indication they will provide the body with fuel and energy required for daily activities and exercise (Wardlaw, 2004, Adegunwa *et al*., 2014).

Table 3: Proximate Composition of Flours (%)

Sample	Moisture	Protein	Fibre	Lipid	Ash	Carbohydrate
MAF	$9.05^{a}\pm0.18$	$9.07^{e}\pm0.20$	$2.15^{d}\pm0.15$	$2.06^{d}\pm0.18$	$1.46^{d}\pm0.10$	$76.02^{a}\pm0.27$
SBF	$8.86^{a}\pm0.20$	$28.42^{a}\pm0.18$	$4.72^{ab}\pm0.12$	$20.64^{c}\pm0.20$	$3.39^{a}\pm0.11$	$33.98^{c}\pm0.20$
GNF	$7.48^{b}\pm0.15$	$18.35^{c}\pm0.15$	$2.25^{d}\pm0.18$	$36.83^{a}\pm0.24$	$1.61^{d}\pm0.13$	$33.69^{c}\pm0.25$
MSF	$7.32^{b}\pm0.18$	$22.65^{b}\pm0.20$	$5.13^{a}\pm0.10$	$17.82^{c}\pm0.20$	$3.58^{a}\pm0.18$	$43.52^{b}\pm0.22$
MGF	$6.28^{d}\pm0.28$	$16.39^{d}\pm0.18$	$3.28^{c}\pm0.13$	$33.08^{b}\pm0.20$	$1.86^{d}\pm0.16$	$39.12^{bc}\pm0.27$
MSG1	$6.44^{d}\pm0.20$	$19.32^{c}\pm0.23$	$4.88^{a}\pm0.15$	$34.86^{a}\pm0.18$	$2.31^{c}\pm0.17$	$32.19^{c}\pm0.20$
MSG2	$7.16^{c}\pm0.18$	$15.47^{d}\pm0.20$	$3.46^{c}\pm0.18$	$34.59^{a}\pm0.26$	$2.47^{c}\pm0.12$	$36.87^{c}\pm0.28$
MSG3	$7.07^{c}\pm0.22$	$20.33^{b}\pm0.27$	$3.88^{c}\pm0.14$	$30.44^{b}\pm0.20$	$2.89^{b}\pm0.18$	$35.42^{c}\pm0.23$
MSG4	$7.88^{b}\pm0.21$	$19.78^{bc}\pm0.18$	$4.39^{b}\pm0.15$	$32.68^{b}\pm0.22$	$2.81^{b}\pm0.18$	32.48 ± 0.24

Values are means ± standard deviation; Superscripts within the same columns are significantly different ($p<0.05$)

Key: MAF = 100% maize, SBF = 100% soybean, **GNF** = 100% groundnut, **MSF** = 50% maize and soybean, **MGF** = 50% maize and groundnut, **MSG1** = 50% maize, 25% each soybean and groundnut, **MSG2** = 50% maize, 10% soybean and 40% groundnut, **MSG3** = 50% maize, 40% soybean and 10% groundnut, **MSG4** = 33.33% each maize, soybean and groundnut

Table 4: Proximate Composition of chin-chin (%)

Sample	Moisture	Protein	Fibre	Fat	Ash	Carbohydrate
MAC	$11.96^{a}\pm0.01$	$9.04^{d}\pm0.01$	$1.22^{d}\pm0.01$	$1.44^{d}\pm0.01$	$1.55^{d}\pm0.01$	$74.79^{a}\pm0.04$
CMS	$6.64^{c}\pm0.03$	$18.55^{c}\pm0.01$	$1.45^{c}\pm0.01$	$14.99^{b}\pm0.01$	$2.67^{c}\pm0.00$	$55.71^{b}\pm0.06$
CFM	$9.64^{b}\pm0.01$	$21.74^{b}\pm0.01$	$2.11^{b}\pm0.01$	$10.97^{c}\pm0.01$	$3.46^{a}\pm0.01$	$52.07^{c}\pm0.01$
FGM	$5.45^{d}\pm0.03$	$26.44^{a}\pm0.01$	$2.68^{a}\pm0.01$	$30.54^{a}\pm0.01$	$3.35^{b}\pm0.01$	$31.54^{d}\pm0.06$

Values are Means ± standard deviation; Means with different superscripts within the same columns are significantly different ($p<0.05$).

Where **MAC**= chin-chin from 100% maize flour, **CMS** = 33.3% each of maize flour, soybean flour and groundnut flour, **CFM** = 50% maize flour, 10% soybean flour and 40% groundnut flour, and **FGM** = 50% maize, 40% soybean and 10% groundnut flours.

Content of Chin-chin Samples

Result of mineral composition of the chin-chin is presented in Table 5 below.

Generally the mineral content of Chin-chin produced from composite flours was higher than those of the control sample. The Calcium and Iron contents of Chin-chin from the composite flours were higher compared to the Control sample (11.81 and 4.41 mg/100g respectively). The results are in agreement with report of Akobundu *et al*. (1998) that in selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential. The components selected for this work complemented each other nutritional by increasing these mineral elements.

Magnesium ranged 82.89 mg/100g (chin-chin from 33.33% each of maize, soybean and groundnut flours) to 211.00 mg/100g (chin-chin from 100% maize) while Potassium ranged from 22.63 mg/100g (chin-chin from 33.33% each of maize, soybean and groundnut flours) to 475.56 mg/100g (100% maize chin-chin). This means that about 100g of these formulated products can provide more than 10% of the recommended calcium intake (Wardlaw, 2004, Onwuka, 2014). The Na/K and Ca/P ratios are indices of body electrolyte balance and bone formation and the values were quite high in this study. The sodium and potassium ratio of less than 1 is recommended for diets (Wardlaw, 2004).

Table 5: Mineral composition of the chin-chin snacks (mg/100g)

Sample	Calcium	Magnesium	Potassium	Iron	Zinc
MAC	$11.81^{d}\pm0.04$	$211.00^{a}\pm1.03$	$475.56^{a}\pm0.06$	$4.41^{d}\pm0.03$	$3.55^{b}\pm0.03$
CMS	$65.52^{c}\pm0.03$	$154.72^{c}\pm0.04$	$251.51^{c}\pm0.04$	$5.18^{b}\pm0.02$	$3.31^{c}\pm0.01$
CFM	$104.82^{a}\pm0.05$	$187.78^{b}\pm0.02$	$260.33^{b}\pm0.08$	$7.02^{a}\pm0.05$	$4.17^{a}\pm0.03$
FGM	$99.54^{b}\pm0.04$	$82.89^{d}\pm0.05$	$22.63^{d}\pm0.03$	$5.04^{c}\pm0.04$	$2.61^{d}\pm0.03$

Values are Means ± standard deviation; Means with different superscripts within the same columns are significantly different ($p<0.05$).

Where: **MAC** = chin-chin from 100% maize flour, **CMS** =33.3% each of maize flour, soybean flour and groundnut flour, **CFM** = 50% maize flour, 10% soybean flour and 40% groundnut flour, **FGM** = 50% maize, 40% soybean and 10% groundnut flours.

Vitamin Content of Chin-chin Samples

The result of the vitamin contents of the chin-chin samples are shown in Table 6.

The samples were not deficient in vitamins. However, there were significant differences (p>0.05) in the vitamin values of the samples. The control (100% maize chin-chin) had the lowest Vitamin A (12.55 mgRE/100g) and chin-chin from (50% maize, 40% soybean and 10% groundnut flours) had the highest (195.01 mg RE/100g), followed by chin-chin from 50% maize, 10% soybean and 40% groundnut flours (121.03 mgRE/100g). This could be attributed to the composite characteristics of their flour components. The vitamins A, B_2 and B_3 values were observed to increase with increase in soybean and groundnut flour inclusion in the chin-chin sample (Adetuyi *et al.*, 2009).Vitamins though required by the body as micro-nutrients are essential for the optimal body function to avoid disease conditions (Wardlaw, 2004).

Table 6: Vitamin composition of the chin-chin snacks

Sample	Vitamin A (mgRE/100g)	Vitamin B1 (mg/100g)	Vitamin B2 (mg/100g)	Vitamin B3 (mg/100g)	Vitamin C (mg/100g)
MAC	$12.55^{d}\pm0.05$	$4.41^{a}\pm0.02$	$0.71^{d}\pm0.03$	$9.01^{d}\pm0.04$	$0.31^{d}\pm0.01$
CMS	$180.11^{b}\pm0.03$	$2.77^{c}\pm0.04$	$1.27^{c}\pm0.02$	$25.87^{c}\pm0.06$	$1.04^{c}\pm0.02$
CFM	$121.03^{c}\pm0.04$	$3.05^{b}\pm0.04$	$1.84^{a}\pm0.04$	$34.41^{b}\pm0.03$	$1.61^{b}\pm0.03$
FGM	$195.01^{a}\pm0.03$	$1.02^{d}\pm0.05$	$1.55^{b}\pm0.05$	$38.51^{a}\pm0.04$	$1.65^{a}\pm0.03$

Values are Means ± standard deviation; Means with different superscripts within the same columns are significantly different (p<0.05).

Where:
MAC = chin-chin from 100% maize flour, **CMS** =33.3% each of maize flour, soybean flour and groundnut flour, **CFM** = 50% maize flour, 10% soybean flour and 40% groundnut flour, **FGM** = 50% maize, 40% soybean and 10% groundnut flours.

Sensory Evaluation of Chin-chin Samples

The result of sensory evaluation of the various chin-chin samples is presented in Table 7.

There were significant ($p<0.05$) differences in the sensory attributes of appearance, flavour and texture of the chin-chin samples. 100% maize chin-chin had the highest score (7.60) for appearance, while chin-chin from 33.3% each maize, soybean and groundnut flours had the lowest (6.60). The blended chin-chin samples had darker shades of appearance. Oduro-Obeng and Plahar (2017) reported low rating for darker appearance as the substitution for wheat flour with soy-flour increased in biscuits. Physical appearance is an important feature of food samples (Oluwole, 2009). Consumers often use appearance of foods to predict quality.

In the taste sensory parameter, the chin-chin products scored fairly with a range of 6.75 (chin-chin from 50% maize, 40% soybean and 10% groundnut flour) to 7.85 (chin-chin from 100% maize flour). There was significant ($p<0.05$) difference in the taste parameter of the chin-chin. Chin-chin from (100% maize flour) and chin-chin from (50% maize, 10% soybean and 40% groundnut flours) with taste mean score of 7.85 and 7.80 respectively (approximately 8) which translates to like very much in the Hedonic scale were mostly preferred and did not differ significantly ($p>0.05$) from each other.

The panellists also preferred the 100% maize Chin-chin (7.30) in terms of their crispy texture compared to the other softer samples from legume blends. Oduro-Obeng and Plahar (2017) reported similar result for grain-legume snacks. However chin-chin from 50% maize, 10% soybean and 40% groundnut flour was mostly preferred (7.45) with regard to the aroma of the samples, the groundnut flavour was better appreciated. Noor *et al.* (2012) reported low preference to be due to beany flavour for legume substituted cookies.

The highest overall acceptability (8.00) was recorded in chin-chin from 100% maize flour. This was closely followed by chin-chin (50% maize, 10% soybean and 40% groundnut flour), which had 7.90 which also translate to “like very much” on the sensory Hedonic scale. However, all the chin-chin produced from the flour blends received acceptable overall acceptability score in the like zone on the Hedonic scale. Oluwole (2009) reported that general/overall acceptability is the combination of all the other sensory parameters and if a product records acceptable quality levels in most of the other parameters, it is expected that such product will have a good overall acceptability.

Table 7: Sensory evaluation of the chin-chin snacks

Sample	Appearance	Taste	Aroma	Texture	Acceptability
MAC	$7.60^{a}\pm1.14$	$7.85^{a}\pm1.23$	$7.00^{b}\pm1.36$	$7.30^{a}\pm1.41$	$8.00^{a}\pm1.38$
CMS	$6.60^{c}\pm1.47$	$7.15^{b}\pm1.50$	$6.95^{bc}\pm1.10$	$7.10^{b}\pm1.33$	$7.41^{b}\pm1.21$
CFM	$7.20^{b}\pm1.28$	$7.80^{a}\pm1.49$	$7.45^{a}\pm1.04$	$7.15^{ab}\pm1.61$	$7.90^{a}\pm1.17$
FGM	$6.85^{bc}\pm1.27$	$6.75^{c}\pm1.28$	$6.65^{c}\pm1.43$	$6.75^{c}\pm1.41$	$6.85^{c}\pm1.23$

Values are Means ± standard deviation determinations; Means with different superscripts within the same columns are significantly different ($p<0.05$).

Where:

MAC = chin-chin from 100% maize flour, **CMS** =33.3% each of maize flour, soybean flour and groundnut flour, **CFM** = 50% maize flour, 10% soybean flour and 40% groundnut flour, **FGM** = 50% maize, 40% soybean and 10% groundnut flours.

CONCLUSION

This study had shown that, blends of maize, soybean and groundnut flours can be used to produce enriched gluten-free chin-chin products that can be generally accepted by the consumers. This will help reduce wheat importation, encourage the production and utilization of local grains and legumes thereby growing the agricultural sector. The increased nutrient content suggests that the product can help alleviate the problem of vital nutrient deficiencies and protein malnutrition among the vulnerable groups.

These composite flours should be used to produce different nutritious food products that are organoleptically acceptable. Food industries are recommended to use these local raw materials than depending on imported flours. Recommendation is therefore made for the production of chin-chin from these composite flour blends especially 50% maize, 10% soybean, 40% groundnut flours and 50% maize, 40% soybean and 10% groundnut due to their high nutrient qualities.

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‘Competing Interest

The authors hereby declare no competing interest whatsoever with regard to this research work.

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