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ABSTRACT

Chinchin has been identified to be one the favoured food items and a much-relished pastry which has been eaten as dessert or snack. This study aimed at evaluating the nutritional quality and organoleptic properties of black-pepper enriched Chinchin produced from plantain-tigernuts composite flour. Matured plantains (*Musa paradisiaca*), tigernuts (*Cyperus esculentus*) and black pepper were processed into flour. Chinchin was processed from different blends of plantain and tigernuts composite flour at the ratio of 100:0, 70:30, 60:40, 50:50, 40:60, 30:70, and 0:100 for plantain and tigernuts respectively. Five percent (5%) black pepper spice was added to each of the samples for Chinchin production. Proximate, mineral and vitamin compositions were determined using standard methods. The results of proximate composition of the different snack samples showed significant differences ($P < 0.05$) with values ranging from 6.50-10.00%, 4.45-6.75%, 2.25-32.75, 1.33-2.00%, 3.50-6.13% and 46.07-78.48% for moisture, protein, fat, ash, crude fibre and carbohydrate contents respectively. There was significant difference ($p < 0.05$) in the minerals and vitamins contents, and organoleptic properties of the black pepper chinchin samples. In conclusion, chinchin of improved and acceptable nutritional and organoleptic properties could be obtained using plantain-tigernuts composite flour and black pepper spice for improved nutrition. This product could add to range of snacks available for those with special dietary needs.

Key words: Plantain flour; Tiger-nut flour; Black pepper; spiced-chinchin; proximate composition

Introduction

In Africa, plantains and bananas provide more than 25 percent of the carbohydrate requirements for over 70 million people (UNCST, 2007). Nigeria is one of the largest plantain producing countries in the world (FAO, 2006). Plantains can be used for cooking at any stage of ripeness, and ripe plantain can be eaten raw. Green plantains are firm and starchy, and resemble potatoes in flavour. They can also be boiled, baked, micro waved or grilled over charcoal, peeled or still in the peel. An average plantain has about 220 calories and is a good source of potassium and dietary fibre. Unripe plantain is traditionally processed into flour in Nigeria and in other west and central African countries (Ukhum and Ukpebor, 1991). The flour produced is mixed with boiling water to prepare an elastic pastry (“amala” in Nigeria and fufou or fufu in Cameroon) which is eaten with various sauces. Plantain flour is however gradually finding applications in weaning food formulation and composite flour preparations (Olaoye et al., 2006; Mepba et al., 2007).

Tigernut (*Cyperus esculentus*) is an underutilized crop in the family of Cyperaceae, which produces rhizomes from the base and tubers that are somewhat spherical. It has been reported to be high in dietary fibre content (Anderson et al., 1994) and it has been demonstrated to be a rich source of quality oil and contains moderate amount of protein. It is also an excellent source of some useful minerals such as iron and calcium (Oladele and Aina, 2007) and rich in vitamins E and C (Rita, 2009 and Adegunwa et al., 2017). It also contains a reasonable amount of methionine lacking in plantain, making it a good supplement for plantain (Ogazi et al., 1996 and Adegunwa et al., 2017). Different kinds of products are obtained from tiger nut which includes; tiger nut flour, Tiger nut oil, tiger nut milk, “Dakuwa” and “kunu” and some of them can be eaten as snack (Gambo and Da’u, 2014). Tigernut flour is considered good flour or additive for the bakery industry, as its natural sugar content is high, avoiding

the necessity of adding too much extra sugar (Anderson *et al.*, 1994). Although, many researchers have worked on tiger nut (De-Vries, 1991, Cortes *et al.*, 2005, Bamigbola *et al.*, 2016 and Adegunwa *et al.*, 2017), yet there is need for increased utilization and awareness about its health benefits.

Black pepper (*Piper nigrum*) is famous as the spices king due to its pungent quality (Srinivasan, 2007). It is a member of family *Piperaceae* (Ahmad *et al.*, 2010; Abbasi *et al.*, 2010). The genus piper has more than 1000 species but the most well-known species are *P. nigrum*, *P. longum* and *P. betle*. *P. nigrum* fruits are also used to produce white pepper and green pepper and are valued due to the presence of piperine including its different isomers (Zaveri *et al.*, 2010). Black pepper can be used for different purposes such as human dietaries as medicine, as preservatives, as biocontrol agents (Srinivasan, 2007, Awen *et al.*, 2010 and Hussain *et al.*, 2011). This plant and its active component piperine can stimulate the digestive enzymes of pancreas and intestines and increases biliary bile acid secretion when orally administered (Tiwari and Singh, 2008). *Piper nigrum* possesses antioxidant activity which is probably due to the presence of flavonoids and phenolic contents (Ahmad *et al.*, 2010). Black pepper is antimicrobial (Wongpa *et al.*, 2007). The effect of intake of peppercorn in food items and oral administration of active compounds of genus piper such as piperine, piperamides, piperamines and pipene on the enzyme's activation of pancreas, liver and the terminal digestive enzymes of the small intestinal mucosa has been reported (Tiwari and Singh, 2008; Awen *et al.*, 2010). Addition of piperine to food substances as food additives increases lipase activity, pancreatic amylase activity, chymotrypsin activation and protease activity (Srinivasan, 2007).

Wheat flour has been solely used to produce deep fat fried and baked products such as, bread, cakes, buns, doughnuts, chin-chin and biscuit. This is because of the nature and functional properties of the wheat flour proteins. But, local climatic conditions in tropical countries such

as Nigeria are not suitable for profitable wheat production. Since 1960, much research aimed at incorporating non-wheat materials of local origin on bread and other flour product was undertaken to limit wheat import (Gomez et al., 1992). The difficulties in the use of non-wheat flour to produce baked goods due to the deficiency of gluten a viscoelastic protein necessitate the search for products which do not require the leavening action of gluten. Such products are mostly deep fat fried products like buns and chin-chin (Opara, 2013). Chin-chin is a fried snack popular in West Africa. It is sweet, hard, doughnut-like baked or fried dough of wheat flour, and other customary baking items. Chin-chin may also contain cowpeas (Akubor, 2004). Many people also bake it with ground nutmeg for flavour. It is usually kneaded and cut into small squares of 1 square inch or so, about a quarter of an inch thick, before frying (Mepba *et al*, 2007). As such chin-chin is easily one of the most favoured food item, a much-relished African pastry which could serve as a dessert, snack and as a popular street food. In fact, it enjoys a very special place in the heart as well as stomachs of West African population (Mepba *et al*, 2007). Recently, natural antioxidants are of special interest to scientists to cure cellular degeneration (Ahmad *et al.*, 2011; Obinna *et al.*, 2009). Successful incorporation of black pepper into chin-chin production is expected to provide a reasonable amount of antioxidant in the diets of its consumers. This study therefore aimed at determining the acceptability of black pepper incorporated chin-chin as well as to evaluate some quality attributes of chin-chin produced from plantain-tigernuts composite flour.

Materials and Methods

Tigernuts (*Cyperus esculentus*) yellow variety, black pepper and matured green ripe and wholesome fruits of plantain was purchased from Kuto market, Abeokuta. Ingredients of chin-chin such as margarine, sugar, salt, nutmeg, egg, and vegetable oil were also purchased from the same market.

Tigernut and plantain Flours Processing

The method described by Adegunwa et al. (2007) was used in the preparation of tigernut and plantain flours. The dried tigernuts and plantain were milled and sieved through 600 μ m mesh size sieve. The resultant flour was packed and sealed in polythene bags.

Black pepper Flour Processing

Black pepper flour was prepared from fresh fruits of fully ripe black pepper (*Piper nigrum*) by water steeping and retting technique described by (Omafuvbe and Kolawole, 2004) with slight modification. Essentially, ripe pepper berries were washed with tap water, packed in muslin bags and soaked in a basin of water for 7 days with daily changes of the steeping water. Retted pepper berries were de-skinned by rubbing with hands and washed in running water. De-skinned berries were dried in the oven at 40°C until a moisture content of 10-12% was achieved (Purseglove *et al.*, 1981). The dried nuts were milled and sieved through 250 μ m aperture size. The resultant flour was packed and sealed in polythene bags.

Composite Flour Preparation

Plantain flour (PF) and Tigernut flour (TF) was blended with different combination manually.

Table 1: Different treatment for composite flour preparation

Table 2: Ingredients Composition for Chin-chin Production.

Processing of Chin-chin

Flour and salt were sieved first into a bowl. Then margarine was mixed together with flour evenly. Egg, sugar and other ingredients was added to make stiff dough. The stiff dough was rolled tightly to 1cm thickness on a board and cut into cubes. Cut dough was fried in deep hot vegetable oil until golden brown colouration was obtained. The fried chin-chin were drained, cooled and packaged.

Determination of Proximate Composition

Proximate composition: protein, ash, moisture content, crude fat, crude fibre and carbohydrate were determined according to the official method of analysis described by the Association of Official and Analytical Chemist (AOAC, 2005).

Mineral Analysis

Five grams (5g) of each sample was heated gently over a Bunsen burner flame until most of the organic matter was destroyed. This was further heated strongly in a muffle furnace for several hours until white-grey ash was obtained. The ash material was cooled. About 20ml of distilled water and 10ml of dilute hydrochloric acid was added to the ashed material. This mixture was boiled, filtered into a 250ml volumetric flask, washed thoroughly with hot water, cooled and made up to volume. Mineral content of each sample was analysed using Atomic Absorption Spectrophotometer (PYE Unicor, UK, model SP9) (AOAC, 1995). Some mineral elements determined include; Potassium, Magnesium, Phosphorus, Calcium and Iron

Vitamin Analyses

Vitamin A (Retinol) and B1 (Thiamine) was determined using AOAC (2005) method and described by Adegunwa et al (2017), while Vitamin E (Tocopherol) was determined using AOAC (1995) method.

Ascorbic Acid (Vitamin C)

Ascorbic acid was determined by dyestuff titration method, Oladeji *et al.*, (2013). Sample (5g) was digested by 0.4% oxalic acid. The aliquot was titrated against dyestuff, which was previously standardized by standard ascorbic acid solution, and the ascorbic acid content was calculated using the following expression.

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titre value} \times 0.606 \times 100}{\text{Weight of Sample}}$$

Sensory attributes of the chin-chin

The sensory attributes of the chin-chin were obtained by using simple hedonic tests as described by Larmond (1991). This was done using a 20-member panel comprising of students of the department of Food Science and Technology, Federal University of Agriculture, Abeokuta, who were familiar with the sensory attributes of chin-chin. Evaluation indexes include Appearance, crispness, crunchiness, taste, colour, flavour and overall acceptance. Each panellist was asked to score each attribute on a 9-point hedonic scale where 9 and 1 represent like extremely and dislike extremely respectively.

Statistical Analysis

The mean \pm standard deviation of the result data from the experiment was calculated and analysed using single factor ANOVA in the statistical package for social science software (SPSS version 17.0 for windows). The Duncan multiple range test was used to separate the differences in the mean scores at significant level of $P=0.05$. Pearson correlation analysis was carried out on the functional properties of the flour and the sensory properties of the fried chin-chin.

Results and Discussions

Table 3 shows the results of the chemical composition of fried Chin-chin. Significant ($p < 0.05$) differences existed in the moisture, ash, protein, fat and total carbohydrate contents of the fried chin-chin. As expected, the ash, protein, fat, and crude fibre content increased as the percentage of tigernuts flour substitution increases, while moisture and carbohydrate increased with increase in plantain flour substitution. The ash content of the fried chin-chin ranged between 1.67 ± 0.00 and $2.53 \pm 0.21\%$, with chin-chin made from 100% tigernut flour having the highest mean value. Ash gives an indication of inorganic elements that are present in a food as minerals. Ash content of the chin-chin were high, indicating that the chin-chin were likely to be good sources of mineral elements. The ash contents of the chin-chin samples obtained in this study were higher compared to the value (1.16 ± 0.00) reported for chin-chin made from 100% wheat flour by Falola *et al.*, (2014).

The fat content of the fried chin-chin ranged from 9.87 ± 0.06 to $35.25 \pm 0.35\%$. The increased substitution of tigernuts flour increased the fat content of the fried chin-chin, which could be of nutritional concern; however, tigernuts fat has been reported to have health benefits (Adejuyitan, 2011; Sánchez-Zapata *et al.*, 2012). Tigernut oil has been reported to reduce low density lipoprotein-cholesterol (LDL-C) and increases high density lipoprotein cholesterol (HDL-C) and, hence, reduces levels of triglycerides in blood and the risk of forming bloody clots, thereby preventing arteriosclerosis (Sánchez-Zapata *et al.*, 2012). It also stimulates the absorption of calcium in bones and the production of new bony material due to presence of short and medium chain fatty acids, oleic acid and essential fatty acids. It has a high oleic acid and low polyunsaturated fatty acid (linoleic acid and linolenic acid) (Ezebor, 2005). It also has higher oxidative stability than other oils, due to the presence of polyunsaturated fatty acids and gamma-tocopherol (Ezebor, 2005). The oil was found to contain 18% saturated

(palmitic acid and stearic acid) and 82% unsaturated (Oleic acid and Linoleic acid) (Zhang *et al.*, 1996). Tigernuts oil has a monounsaturated profile (>60% monounsaturated fatty acids [MUFA]), with a similar fatty acid (FA) profile to olive oil (Sánchez-Zapata *et al.*, 2012). Tiger nut oil was considered a generally healthier alternative.

Table 3: Proximate composition of plantain-tiger nut black pepper spiced chin-chin.

The moisture content of the chin-chin ranged from 2.84 ± 0.23 to $5.09 \pm 0.12\%$. Moisture provides a measure of the water content and an index of storage stability of the food. Sanni *et al.* (2006) reported that the lower the moisture content of a product to be stored the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried product. Therefore, the low moisture content of all the fried chin-chin makes them less liable to microbial attack than the raw material (plantain and tigernuts) and would have longer shelf stability. The protein content of the fried chin-chin ranged from 5.43 ± 0.25 to $9.57 \pm 0.09\%$. The protein content of the chin-chin samples increased as the level of tigernuts flour substitution increases. The protein content of chin-chin made from 100% tigernuts flour obtained in this study was higher than the value ($9.25 \pm 0.07\%$) reported for chin-chin made from 100% wheat flour by Falola *et al.*, (2014).

The crude fibre content of the fried chin-chin ranged from 3.64 ± 0.02 to $6.28 \pm 0.11\%$. The crude fibre content of the fried chin-chin increased as the level of tigernuts flour substitution increases. The result of crude fibre content for chin-chin made from 100% tigernuts flour in this study is higher than the value (5.19%) reported for chin-chin made from 100% wheat flour by Adegunwa *et al.*, (2014). Nutritional claims for dietary fibre foods (Official Journal of European Commission, 2006) recommended that for a product to be labelled as “source of fibre” it must contain >3g dietary fibre/100 g food. Since the fried chin-chin samples obtained in this study contain more than 3g dietary fibre/100g, the fried chin-chin can be

regarded as “source of dietary fibre”. The carbohydrate content of the chin-chin samples ranged from 43.55 ± 0.40 to $74.41 \pm 0.33\%$; the chin-chin produced from 100% plantain flour had the highest mean value. The results showed that the carbohydrate content decreased with increasing level of tigernuts flour substitution. The carbohydrate content of chin-chin made from 100% plantain flour obtained in this study was higher than the value (57.41%) reported for chin-chin made from 100% wheat flour by Adegunwa *et al.*, (2014).

The results of the mineral composition of the fried chin-chin are shown on Table 4. The results show that there is significant difference ($p < 0.05$) in the mineral composition of the fried chin-chin. The Magnesium content of the fried chin-chin ranges between 21.43 ± 0.11 and $32.28 \pm 0.04 \text{mg}/100\text{g}$, while the Phosphorus content ranges between 26.51 ± 0.83 and $113.62 \pm 2.03 \text{mg}/100\text{g}$. There is increase in magnesium and phosphorus content of the chin-chin as the level of tigernuts flour substitution increases. This implied that Chin-chin produced from 100% tigernuts flour has the highest magnesium and phosphorus content, while chin-chin produced from 100% plantain flour has the lowest mean value.

The Potassium content of the fried chin-chin ranges between 64.89 ± 0.48 and $193.78 \pm 6.50 \text{mg}/100\text{g}$. Chin-chin produced from 100% tigernuts flour has the highest mean value while chin-chin produced from 100% plantain flour has the lowest mean value. The Iron content of the fried chin-chin ranges from 0.14 ± 0.10 to $0.35 \pm 0.06 \text{mg}/100\text{g}$. The Iron content of the fried chin-chin also increases as the level of tigernuts flour substitution increases. The Calcium content of the fried chin-chin ranges between 2.35 ± 0.07 to $7.03 \pm 0.04 \text{mg}/100\text{g}$. Chin-chin produced from 100% plantain flour has the highest mean value for Calcium, while chin-chin produced from 100% tigernuts flour has the lowest value.

Table 4: Mineral Composition of Plantain-Tigernuts Black Pepper Spiced Chin-chin.

The vitamin results of the fried chin-chin were shown on Table 5. The results show that there is significant difference ($p < 0.05$) in the vitamin composition of the fried chin-chin. The vitamin C content of the fried chin-chin ranges between 0.76 ± 0.21 and 2.27 ± 0.21 mg/100g. Increase in the level of tigernuts flour substitution increases the vitamin C content of the chin-chin. The mean value of vitamin B1 content of the fried chin-chin ranges from 0.011 ± 0.00 to 0.015 ± 0.00 mg/100g. Increase in the level of tigernuts flour substitution decreases the vitamin B1 content of the chin-chin.

The vitamin A content of the fried chin-chin ranges between 15.59 ± 0.72 to 53.26 ± 0.39 mg/100g. There is increase in the vitamin A content of the Chin-chin as the level of tigernuts flour substitution increases. This shows that tigernuts is richer in vitamin A than Plantain. The results of the vitamin E content ranges from 0.15 ± 0.01 to 5.35 ± 0.63 mg/100g for the fried chin-chin. There is also increase in vitamin E content of the fried chin-chin as the level of tigernuts flour substitution increases. Generally, the results obtained in this study have shown that as the level of tigernuts flour substitution increases the mineral and vitamin contents increases. This indicated that tigernuts flour is richer in vitamins and mineral elements than plantain flour and could therefore be consider a good supplement for plantain flour.

Table 5: Vitamin Composition of Plantain-Tigernut Black pepper Spiced Chin-chin.

Table 6 shows the mean sensory scores for plantain-tigernuts black pepper spiced chin-chin. There were significant differences ($P < 0.05$) in terms of appearance, taste, flavour and crunchiness. Meanwhile, no significant difference ($P < 0.05$) was observed in terms of colour, crispiness and overall acceptability. The mean value for the appearance of the chin-chin ranges from 6.45 ± 1.28 to 7.35 ± 1.09 mg/100g, with chin-chin made from 100% plantain flour having the highest mean value and consequently, the most accepted in terms of appearance. The mean value scores of chin-chin in terms of taste and flavour ranges from 5.45 ± 2.14 to

7.30±1.34mg/100g and 5.40±1.79 to 7.00±1.26mg/100g respectively, with chin-chin produced from 100% tigernuts flour having the highest mean value and consequently the most accepted in terms of taste and flavour. Tigernut flour has been described as having good taste and distinct flavour, such that it is used as flavouring agent for ice cream and biscuit (Osagie and Eka, 1998).

The mean value scores for crunchiness ranges between 5.70±1.38 to 7.25±1.16mg/100g. The crunchiness of the fried chin-chin decreases as the level of tigernuts flour substitution increases. This shows that the chin-chin samples produced from 100% plantain flour is the crunchiest among the chin-chin samples.

Table 6: Sensory Properties of Plantain-Tigernut-Black Pepper Spiced Chin-chin

The mean value scores for the chin-chin in term of colour, crispiness and overall acceptability ranges from 6.65±1.23 to 6.80±1.11mg/100g, 6.45±1.05 to 6.75±0.97mg/100g and 6.55±1.54 to 7.15±1.60mg/100g respectively. In terms of colour and crispiness, chin-chin made from 100% plantain flour (sample A) has the highest values. However, there was no significant difference among the mean value score of the samples. In terms of overall acceptability, all the samples were accepted as there was no significant difference among the mean value scores for the samples. However, sample B produced from 70% plantain flour and 30% tigernuts flour has the highest mean value score for overall acceptability. The incorporation of black pepper spice into foods production is feasible as evident in the results obtained from this study and could improve food digestibility. The black pepper spiced chin-chin could therefore be used as an appetizer.

Correlation study of the relationship between functional properties of the composite flour samples and sensory qualities of the plantain-tigernuts black pepper spiced chin-chin indicated significantly ($p < 0.05$) high negative correlation ($r^2 = -0.78$) between oil absorption capacity and flavour, while Emulsion activity compared with Crunchiness

indicated high negative significant ($p < 0.05$) correlation ($r^2 = -0.893$), as shown in table 7. The negative association indicated that as the oil absorption capacity decreases, flavour increases while increasing emulsion activity decreases crunchiness.

Table 7: Pearson's Correlation Matrix between Functional and Sensory Properties of Chinchin

Conclusion

This study has demonstrated the possibility of compositing plantain and tigernuts flour at varying proportions in the production of snacks (chin-chin). Increased substitution of tigernuts flour considerably enhanced the protein, fat, ash, the dietary fibre contents, mineral, vitamin content and sensory properties (such as taste and flavour) of the snack (chin-chin). While increased substitution of plantain flour improves the carbohydrate content of the chin-chin. It also improves sensory properties such as crispiness and crunchiness and has the highest mean score in terms of appearance. This study has also shown successful incorporation of black pepper into snacks (chin-chin) production. This study has shown that incorporation of black pepper spice into chin-chin production will enhance commercial utilization of black pepper in food formulations.

Data availability: All the data for this study are used for data analysis and results are presented in this article

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Conflicts of Interest: The authors declare no conflict of interest.

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Table 1: Different treatment for composite flour preparation

Treatment	Plantain flour (%)	Tiger nut flour (%)	Sample code
T1	100	0	A
T2	0	100	B
T3	70	30	C

T4	60	40	D
T5	50	50	E
T6	40	60	F
T7	30	70	G

Table 2: Ingredients Composition for Chin-chin Production.

Ingredients	Weight (g)
Flour	200g
Fat	4g
Sugar	40g

Salt	2g
Sodium bicarbonate	2g
Egg	50g
Water	20ml
Nutmeg	4
Black pepper spice	10g

Source: Evelyn, (2007) with slight modification.

Table 3: Proximate composition of plantain-tiger nut black pepper spiced chin-chin.

Sample	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)	Crude Fibre (%)	CHO (%)
A	5.09±0.12 ^a	5.43±0.25 ^d	9.87±0.06 ^g	1.67±0.00 ^b	3.64±0.02 ^c	74.41±0.33 ^a
B	4.25±0.35 ^b	7.18±0.25 ^c	14.34±0.56 ^f	1.70±0.04 ^b	4.49±0.02 ^d	68.06±0.10 ^b
C	3.49±0.23 ^c	7.37±0.10 ^{bc}	19.91±0.41 ^e	1.70±0.04 ^b	4.56±0.06 ^d	62.94±0.68 ^c
D	3.17±0.24 ^{cd}	7.44±0.00 ^{bc}	22.62±0.17 ^d	1.70±0.04 ^b	4.64±0.17 ^d	60.44±0.06 ^d
E	3.17±0.24 ^{cd}	7.47±0.04 ^{bc}	25.67±0.47 ^c	1.87±0.28 ^b	5.29±0.13 ^c	56.54±1.16 ^c
F	3.09±0.12 ^{cd}	7.64±0.03 ^b	30.07±0.11 ^b	1.86±0.20 ^b	5.64±0.09 ^b	51.71±0.09 ^f
G	2.84±0.23 ^d	9.57±0.09 ^a	35.25±0.35 ^a	2.53±0.21 ^a	6.28±0.11 ^a	43.55±0.40 ^g

Values are means and standard deviation (±) of replicate determination. Values with different superscript in the same column are significantly different at p<0.05. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tiger nut flour, C: 60% plantain flour and 40% tiger nut flour, D: 50% plantain flour and 50% tiger nut flour, E: 40% plantain flour and 60% tiger nut flour, F: 30% plantain flour and 70% tiger nut flour, G: 100% tiger nut flour

Table 4: Mineral Composition of Plantain-Tigernuts Black pepper Spiced Chin-chin.

Sample/Component	Magnesium (mg/100g)	Phosphorus (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)
A	21.43±0.11 ^f	26.51±0.83 ^g	64.89±0.48 ^g	0.14±0.10 ^d	7.03±0.04 ^a
B	24.34±0.53 ^e	43.86±0.23 ^f	95.42±0.64 ^f	0.19±0.01 ^{cd}	5.73±0.07 ^b
C	26.86±0.09 ^d	58.55±0.64 ^e	118.18±0.13 ^e	0.22±0.01 ^{bc}	4.99±0.01 ^c
D	28.98±0.09 ^c	68.34±0.55 ^d	138.20±0.39 ^d	0.25±0.01 ^b	4.16±0.09 ^d
E	31.07±0.01 ^b	82.18±0.04 ^c	148.60±0.92 ^c	0.27±0.00 ^b	3.86±0.20 ^e
F	31.38±0.68 ^b	95.02±0.28 ^b	175.92±0.13 ^b	0.33±0.01 ^a	2.99±0.21 ^f
G	32.28±0.04 ^a	113.62±2.03 ^a	193.78±6.50 ^a	0.35±0.06 ^a	2.35±0.07 ^g

Values are means and standard deviation (\pm) of replicate determination. Values with different superscript in the same column are significantly different at $p < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tiger nut flour, C: 60% plantain flour and 40% tiger nut flour, D: 50% plantain flour and 50% tiger nut flour, E: 40% plantain flour and 60% tiger nut flour, F: 30% plantain flour and 70% tiger nut flour, G: 100% tiger nut flour.

Table 5: Vitamin Composition of Plantain-Tigernut Black pepper Spiced Chin-chin.

Sample/ Component	Vitamin C (mg/100g)	Vitamin B1 (mg/100g)	Vitamin A (μ g/100g)	Vitamin E (mg/100g)
A	0.76 \pm 0.21 ^d	0.015 \pm 0.00 ^a	15.59 \pm 0.72 ^f	0.15 \pm 0.01 ^e
B	1.14 \pm 0.11 ^{cd}	0.014 \pm 0.00 ^{ab}	18.92 \pm 0.83 ^c	1.27 \pm 0.02 ^d
C	1.29 \pm 0.11 ^c	0.014 \pm 0.00 ^{abc}	33.58 \pm 0.53 ^d	2.48 \pm 0.24 ^c
D	1.69 \pm 1.84 ^b	0.013 \pm 0.00 ^{bcd}	36.82 \pm 0.47 ^c	2.83 \pm 0.09 ^c
E	1.72 \pm 1.49 ^b	0.012 \pm 0.00 ^{cd}	38.12 \pm 0.10 ^b	3.21 \pm 0.32 ^c
F	1.90 \pm 0.11 ^{ab}	0.011 \pm 0.00 ^d	39.14 \pm 0.30 ^b	4.27 \pm 0.54 ^b
G	2.27 \pm 0.21 ^a	0.011 \pm 0.00 ^d	53.26 \pm 0.39 ^a	5.35 \pm 0.63 ^a

Values are means and standard deviation (\pm) of replicate determination. Values with different superscript in the same column are significantly different at $p < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tiger nut flour, C: 60% plantain flour and 40% tiger nut flour, D: 50% plantain flour and 50% tiger nut flour, E: 40% plantain flour and 60% tigernuts flour, F: 30% plantain flour and 70% tiger nut flour, G: 100% tiger nut flour.

Table 6: Sensory Properties of Plantain-Tigernut-Black Pepper Spiced Chin-chin

Sample	Appearance	Taste	Crispness	Flavour	Crunchiness	colour	Overall acceptability
A	7.35 \pm 1.09 ^a	5.45 \pm 2.14 ^b	6.75 \pm 0.97 ^a	5.40 \pm 1.79 ^b	7.25 \pm 1.16 ^a	6.80 \pm 1.11 ^a	6.55 \pm 1.54 ^a
B	7.30 \pm 0.92 ^{ab}	6.65 \pm 1.63 ^a	6.55 \pm 1.40 ^a	6.25 \pm 1.29 ^{ab}	7.15 \pm 0.81 ^{ab}	6.70 \pm 1.03 ^a	7.15 \pm 1.60 ^a
C	7.00 \pm 1.08 ^{abc}	6.80 \pm 1.71 ^a	6.45 \pm 1.05 ^a	6.30 \pm 1.53 ^{ab}	7.00 \pm 0.86 ^{ab}	6.70 \pm 1.22 ^a	7.00 \pm 0.92 ^a
D	6.65 \pm 0.99 ^{abc}	6.90 \pm 1.02 ^a	6.55 \pm 1.32 ^a	6.55 \pm 1.10 ^a	6.65 \pm 0.93 ^{ab}	6.70 \pm 1.03 ^a	6.95 \pm 0.95 ^a
E	6.60 \pm 1.10 ^{bc}	6.90 \pm 1.29 ^a	6.66 \pm 1.54 ^a	6.75 \pm 1.52 ^a	6.60 \pm 1.10 ^{ab}	6.75 \pm 1.83 ^a	7.10 \pm 0.91 ^a
F	6.45 \pm 0.69 ^c	7.00 \pm 1.17 ^a	6.60 \pm 1.10 ^a	6.90 \pm 1.17 ^a	6.35 \pm 1.73 ^{bc}	6.65 \pm 1.09 ^a	7.05 \pm 1.10 ^a
G	6.45 \pm 1.28 ^c	7.30 \pm 1.34 ^a	6.70 \pm 1.46 ^a	7.00 \pm 1.26 ^a	5.70 \pm 1.38 ^c	6.65 \pm 1.23 ^a	7.05 \pm 1.50 ^a

Values are means and standard deviation (\pm) of replicate determination. Values with different superscript in the same column are significantly different at $p < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tiger nut flour, C: 60% plantain flour and 40% tiger nut flour, D: 50% plantain flour and 50% tiger nut flour, E: 40% plantain flour and 60% tiger nut flour, F: 30% plantain flour and 70% tiger nut flour, G: 100% tiger nut flour.

Table 7: Pearson's Correlation Matrix between Functional and Sensory Properties of Chinchin

Quality Parameters	WAC	OAC	BD	SI	FC	EA	CLR	TASTE	FLVR	CRISP	CRN
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WAC	1.000											
OAC	0.956**	1.000										
BD	-0.624*	-0.766**	1.000									
SI	-0.870**	-0.943**	0.790**	1.000								
FC	-0.822**	-0.903**	0.851**	0.966**	1.000							
EA	-0.798**	-0.840**	0.721**	0.943**	0.948**	1.000						
CLR	0.169	0.111	0.355	-0.137	-0.019	-0.180	1.000					
TASTE	-0.695**	-0.767**	0.713**	0.670**	0.700**	0.533**	0.085	1.000				
FLVR	-0.650*	-0.781**	0.846**	0.734**	0.780**	0.610*	0.216	0.950**	1.000			
CRISP	0.083	0.105	-0.086	-0.004	-0.027	0.076	-0.071	-0.130	-0.173	1.000		
CRN	0.762**	0.803**	-0.712**	-0.855**	-0.889**	-0.893**	0.051	-0.500	-0.601*	0.163	1.000	

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

EA–Emulsifying Activity, BD–Bulk density, FC – foaming capacity, SI–Solubility Index, FLVR – sensory flavour, CRISP – crispness, CRN – crunchiness, WAC–Water absorption capacity, OAC–oil absorption capacity, CLR–Sensory color.

Public interest statement

Our study adds value to the current food science and nutrition research that gave information on the nutritional and sensory properties of novel snack product from plantain-tigernuts flours spiced with black pepper. Recently, natural antioxidants are of special interest to scientists to cure cellular degeneration. Successful incorporation of black pepper into chin-chin production is expected to give a reasonable amount of antioxidant in the diets of its consumers. For a quick understanding of the importance of this study, the following results obtained have shown that:

- i. addition of tiger nuts flour improved the proximate composition of the fried chin-chin.
- ii. as the level of tigernuts flour substitution increases, the mineral and vitamin contents increase. This showed that tiger nuts flour is richer in vitamins and mineral elements could, therefore, be considered a good supplement for plantain flour.
- iii. Chin-chin of acceptable quality could be obtained from plantain-tigernuts composite flour.
- iv. Black pepper could be successfully incorporated into the recipes as a spice.

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