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Quality Attributes of Wheat-Tigernut Flour Blends and Chin-Chin Produced from the Blends

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Abstract

This study evaluated the physicochemical, functional and proximate composition of wheat and tigernut composite flour; and proximate composition and sensory properties of Chin-chin produced from the wheat-tigernut flours blends. The addition of tigernut flour to wheat was 10, 20, 30 and 40% representing sample A – D while 100% wheat flour (sample E) served as control. Analyses were by standard analytical procedures. pH, titratable acidity and viscosity of the flour samples ranged from 4.03 - 4.37, 0.39 - 0.80 %Lactic acid, and 9.38 - 9.58 Pa.s respectively, while sugar was 1.00 ^{0}Brix across all samples. Oil absorption capacity, water absorption capacity, dispersibility, solubility index, swelling power, bulk density and foaming capacity varied respectively from 1.22 - 1.40 g/g 1.14 - 1.34 g/g, 2.00 - 4.13%, 35.00 - 37.00 g/g, 6.45 - 7.48 g/g, 0.83 - 0.90 g/ml and 5.00 - 20.00%. Proximate composition of the flour blends varied respectively, from 5.55 - 8.79, 9.28-18.36, 2.12 - 10.91, 1.70 - 2.01, 1.31- 4.17 and 64.78-74.06% for moisture, protein, fat, ash, crude fibre, and % carbohydrates. While energy value of the flours ranged from 351.89 - 405.32 kcal/100g. *Chin-chin* had moisture, protein, fat, ash, crude fibre, carbohydrate and energy contents of 1.85 - 8.64, 10.06 - 16.18, 24.25 - 34.29, 1.20 - 1.70, 14.65 - 27.42, 20.79 - 41.65% and 418.03 - 493.27 kcal/100g respectively. Assessor's degree of likeness for the *chin-chin* ranged from 2.85 - 7.15, 3.56 - 7.85, 3.05 - 6.60, 3.25 - 7.10, 3.65 - 8.00 and 3.06 - 7.26 respectively, for aroma, appearance, colour, crunchiness, taste, and overall acceptability. Tigernut inclusion led to a significant ($p<0.05$) increase in ash, fibre and carbohydrate while moisture decreased. Chin-chin from sample A with 10% tigernut flour had the highest degrees of likeness followed by sample B with 20% tigernut flour. For diversification in the use of tigernut flour, the inclusion of up to 20% can be recommended for full application in the baking industry.

Keywords: *Chin-chin, tigernut flour, proximate composition, physicochemical, functional and sensory properties*

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1. Introduction

Consumers are becoming increasingly health conscious, and this has led to an increase in the demand for healthy snack alternatives that maintain taste and texture while incorporating functional ingredients. Therefore, the food industry is constantly seeking innovative ways to improve the nutritional value and quality of food products (Ugwuanyi, 2020). Snacks form an essential portion of many consumers' daily nutrient and calorie intake (Awoyale *et al.*, 2011). Snack meals are inexpensive, quick to consume and widely accessible on the streets, in stores and in schools among others (Ugwuanyi, 2020). The most widely eaten snacks are cereal-based goods, which generally are poor in nutritional density. They are widely regarded as convenience food and has been part of the human diet for a long time (Lasekan and Akintola, 2002).

Wheat (*Triticum spp.*) has been the major cereal grain used in the bakery industry due to its gluten protein's ability to form viscoelastic dough required to bake leavened bread (Abioye *et al.*, 2020). These gluten proteins are necessary to produce the great variety of foods associated with wheat around the world (FAO/UN, 2016). Therefore, it has a great impact on the nutritional quality of the meals consumed by many people and consequently on their health. Although wheat's ability to produce high yields under a wide range of conditions is one reason for its popularity compared to other cereals, the most important factor is the capability of wheat gluten proteins to form viscoelastic dough.

Tigernut (*Cyperus esculentus*) is a rhizome spherical crop that can be eaten raw, dry, or processed (Bazine and Arslanoğlu, 2020). In Nigeria, tigernut is known as Aya in the North, Ofio in the West, and Akiausa in the South-East. Tigernut unique sweet taste makes it ideal for different food processes. It is a good alternative to many other flours (Ezeocha and Onwumere, 2016) as it is gluten-free and good for people who cannot take gluten in their diets. Tigernut was reported to be high in dietary fibre content, which could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetes, and gastrointestinal disorders (Viuda-Martos *et al.*, 2010). The flour 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 minerals such as iron and calcium which are essential for body growth and development (Oladele and Aina, 2007). Therefore, tigernut with its inherent nutritional and therapeutic advantage, could serve as a good alternative in the baking industry and reduced cost; thereby promoting the utilization of indigenous crops in food formulation (Bosch *et al.*, 2005).

Chin-chin is mostly a fried snack popular in West African countries notably Nigeria. It is a sweet, firm, fried or baked product consisting of wheat flour dough and other components (Akubor, 2007; Mepba *et al.*, 2007). The snack is high in carbohydrate and energy but is low in protein and dietary fibre. To improve the nutritional value of chin-chin, studies have been conducted to enrich its nutritional profile by incorporating different flours and ingredients such as plantain flour and sweet potato flour (Mepba *et al.*, 2007). Tigernut with its known nutrient composition and health benefits can as well be included in wheat flour for various purposes. This study was therefore aimed at evaluation of the physicochemical, functional and proximate composition of composite flour of wheat and tigernut flours and also the proximate composition and sensory properties of the *chin-chin* produced from the flour blends.

2. Materials and Methods

2.1 Raw Materials, *Chin-chin* Ingredients and Analytical Chemicals

Wheat grains, tigernut tubers and all the ingredients used in the *chin-chin* production: egg, margarine, sugar, nutmeg, salt, vegetable oil and milk, were purchased at Mile 1 market in Diobu, Port Harcourt, Rivers State, Nigeria. Chemicals used were of analytical grades obtained from the Food Analysis Laboratory, Department of Food Science and Technology, Rivers State University.

2.2 Production of Tigernut flour

Tigernut flour was prepared using the method described by Ade-Omowaye *et al*. (2008) with some modifications. The tubers were sorted to remove unwanted materials like pebbles, stone, and foreign seeds, then washed with water. The cleaned nuts were dried at 60°C for 12 h, milled and sieved through 100 ųm aperture size sieve and the resultant flour was packaged in ziploc bag and stored for further use.

2.3 Production of Wheat flour

Wheat flour was produced according to the method described by Offia and Onwubiko (2015) with slight modifications. Whole wheat grains were sorted, washed oven dried at 80°C for 6 h, and dry milled with a grinding machine to obtain whole wheat flour. The flour was sieved through a 100 ųm aperture size sieve, packaged in ziploc bag and stored till required for analysis.

2.4 Formulation of Wheat and Tigernut flour blends

Wheat and tigernut flour were mixed at the ratio of 90:10, 80:20, 70:30, 60:40 for samples A, B, C and D while 100% wheat flour as sample E served as control. The flour blends were homogenised using a Kenwood mixer (A90IE, Kenwood Haunt Hampshire, England) to achieve uniform blends and stored in well labelled ziploc bags till needed for analysis.

2.5 Production of Wheat-Tigernut *Chin-chin*

The method of Adegunwa *et al*. (2014) with slight modifications was adopted for the chin-chin production. Dry ingredients: 2 g of salt, 0.5 g of ground nutmeg, 1 g of baking soda, 2 g of powdered milk, 0.5 g of vanilla flour and 25 g of sugar was added to each set of flour blend in a bowl and mixed properly. Thereafter, 25 g of margarine, 1 medium size egg, and 65 ml of water was added, thoroughly mixed and kneaded to make stiff dough. The dough was flattened on a board to a thickness of 1 cm and cut into cubes of 1 cm each, that was deep fried in hot oil until golden brown. The chin-chin was allowed to drain off oil, cooled and packaged in high density polythene bags for storage until the chin-chin was evaluated.

2.6 Determination of Physicochemical Properties of the Wheat-Tigernut Flour Blends

pH, titratable acidity (as % lactic acid), total soluble solid (°Brix) and viscosity was determined using AOAC (2012) standard method. The samples (2 g) were homogenized in 20 mL of distilled water and filtered into a beaker. The pH meter (Jenco 6177) after calibration and stabilization with standard buffer of pH 4.0 and 7.0, was used to determine the sample pH. Thereafter, 3 drops of phenolphthalein were added as the indicator and the mixture was titrated against 0.1 M NaOH. Acidity was expressed as % lactic acid with each ml of the 0.1 M NaOH equivalent to 0.0908 of lactic acid. Total soluble solids content was determined at 29±2°C using Abbe hand refractometer. The sugar content percentage (soluble sugar) was read from the scale of the refractometer when held close to the eye. Viscosity of the 10 g of the flour sample in 100 mL of distilled water was determined using Rotary Viscometer (NDJ-85, China).

2.7 Determination of functional properties of the wheat-tigernut flour blends

Water and oil absorption capacity, loose and packed bulk density, least gelation concentration, dispersibility and foaming capacity were determined according to the method described by Onwuka (2005). Swelling power and solubility were determined according to the method described Aidoo *et al*. (2022). Briefly, water and oil absorption capacity were determined by centrifugal-gravimetric method after the centrifugation of 1 g of the samples in 10 mL of distilled water and pure gino oil respectively. Loose and packed bulk density was determined gravimetrically before and after gentle tapping of 10 mL graduated cylinder filled with the samples until there was no further diminution of the sample levels. Least gelation concentration was determined as the concentration when the sample heated, cooled and held at 40°Cfor 2 h could not slip or fall from the inverted test tube. Dispersibility was determined gravimetrically after 5 g of the homogenized samples in 100 mL of distilled water were allowed to stand for 3 h. Swelling power and solubility were determined gravimetrically after heating to 85°C, holding for 30 min before centrifugation at 1000 rpm for 15 min. Swelling capacity was calculated by dividing the sediment weight with the sample weight. The soluble component in the supernatant after evaporation of water was used in the computation of solubility (%) by dividing the soluble component weight with the sample weight multiplied by 100.

2.8 Determination of Proximate Composition and Energy Value of the Flour and *Chin-chin* Samples

The moisture, protein, crude fibre, fat and ash contents of samples were analysed using the standard analytical method described by Association of Official Analytical Chemists (2012). Moisture was obtained gravimetrically after drying to a constant weight at 70ºC in a hot air oven (DHG 9140A). Fat was determined using soxhlet extraction method with ethyl ether. Kjeldahl method and a nitrogen conversion factor of 6.25 was used for crude protein determination. Ash content was determined gravimetrically after the incineration of the samples in a muffle Furnace (Model SXL) at 550ºC for 2 h. Enzymatic gravimetric method was utilized in the determination of crude fibre. Carbohydrate was calculated by difference {100 - (Crude protein + crude fibre + ash + fat)}. Energy values were obtained using Atwater factor of 4 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat.

2.9 Sensory Evaluation of wheat-tigernut *Chin-chin*

Twenty (20) member panelists consisting of students of the Rives State University, Port Harcourt who are regular consumer of *chin-chin* were used for the sensory evaluation. The samples were evaluated for colour, aroma, crunchiness, taste, appearance and overall acceptability. Each attribute was rated on a 9-point hedonic scale where: 1 = dislike extremely, 2 = dislike very much, 3 = dislike slightly, 4 = dislike moderately, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = liked very much, 9 = liked extremely (Iwe, 2010).

2.10 Statistical Analysis

Analyses were carried out in duplicates. Data obtained were subjected to Analysis of Variance (ANOVA). Difference between means were evaluated using Tukey's multiple comparison tests at 95% confidence level using Minitab (Release 18.1) statistical software English (Minitab Ltd. Conventry, UK).

3. Results and Discussion

3.1 Physicochemical Properties of Wheat-Tigernut flour Blends

The result of the physicochemical properties of the wheat-tigernut flour blends is shown in Table 1. pH varied significantly (P<0.05) from 4.03-4.37 for sample A and D respectively. Samples A and B recorded pH values lower than the control (sample E), indicating that 10 and 20% inclusion of tigernut flour reduced the pH of wheat flour. The pH values however increased on inclusion of 30% (sample C) and 40% (sample D) tigernut flour. The pH values of flours recorded here differs from 5.62-5.92 reported by Akojo and Coker (2018). An acidic pH according to Ogunjobi and Ogunwolu (2010) is associated with the development of a pleasant taste. Titratable acidity as % Lactic acid (TTA) ranged from 0.39-0.80. Sample E recorded the least TTA value and sample A had the highest. The TTA of wheat flour recorded here (0.39%) were similar to 0.32% reported by Akojo and Cooker (2018) for 100% wheat. The TTA values of composite flours from this research (0.45-0.80%) however differs from 0.13-0.29% reported by Akojo and Cooker (2018). There was significant (P<0.05) variation in the samples' viscosity, which ranged from 9.38 - 9.58 Pa.s for sample C and B respectively. Viscosity is an important determinant factor of good quality flour as higher viscosity is required to prevent phase separation during mixing, flow time and oven baking. The Brix value reflects the amount of sugar present in a sample, and expressed in terms of the percentage of the sucrose content. The total soluble solid (^{0}Brix) content had the value of 1.00 across all samples. Sugar is important in baked products for taste (sweetness), flavour, structure and texture (Van der Sman and Renzetti, 2021; Zhou *et al*., 2014). Sugar can lock in moisture which prevents drying out in backed products and also prevents the development of gluten which keeps products such as cookies softer.

Table 1. Physicochemical Properties of Wheat -Tigernut Flour Blends

Sample	pH	Titratable acidity (%Lactic acid)	Viscosity (Pa.s)	Total soluble solids (^{0}Brix)*
A	$4.03^c \pm 0.02$	$0.80^a \pm 0.04$	$9.46^{ab} \pm 0.06$	1.00 ± 0.00
B	$4.04^c \pm 0.01$	$0.45^c \pm 0.00$	$9.58^a \pm 0.02$	1.00 ± 0.00
C	$4.29^{ab} \pm 0.02$	$0.70^{ab} \pm 0.03$	$9.38^b \pm 0.03$	1.00 ± 0.00
D	$4.37^a \pm 0.03$	$0.63^b \pm 0.00$	$9.46^{ab} \pm 0.03$	1.00 ± 0.00
E	$4.21^b \pm 0.04$	$0.39^c \pm 0.04$	$9.43^b \pm 0.01$	1.00 ± 0.00

Values are means ± standard deviation of duplicate samples. Means on the same column that do not share same letter are significantly different (P<0.05)
**No significant (P<0.05) differences among the samples for Total soluble solids*
A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour

3.2 Functional Properties of Wheat-Tigernut flour Blends

Functional properties are those parameters that determine the application and end-use of food materials for various food products (Oluwole *et al.*, 2016). Water and oil absorption capacity, loose and packed bulk density and least gelation concentration (LGC) of the wheat - tigernut flour blends are shown in Table 2. While dispersibility, foaming capacity, swelling power and solubility of the wheat-tigernut flour blends are shown in Figure 1.

There were no significant (P>0.05) differences in the water absorption capacity, oil absorption capacity, loose bulk density and least gelation concentration (LGC) of the samples. The values ranged from 1.22 - 1.40 g/g, 1.14 - 1.34 g/g and 0.45 - 0.50 g/ml respectively for water absorption capacity (WAC), oil absorption capacity (OAC) and loose bulk density (LBD) while all the samples had least gelation concentration (LGC) of 0.20%. The result of the WAC was similar to the report of 1.00 – 2.90 by Obinna-Echem *et al*. (2020) for cowpea-tigernut flours blends. Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting, such as dough and pastes. The results obtained suggest that wheat-tigernut flour blends would be useful in food systems such as bakery products. The OAC was in line with Bello *et al.* (2020) who reported OAC of 1.25-1.9 g/g for different ratios of complementary foods from maize, carrot and pigeon pea. WAC and OAC indicates enhanced hydrophobic character of proteins in flour (Kalar *et al*., 2022). Low OAC indicates that the flour when used in products that require frying would not absorb much oil. This a good quality for *chin-chin* production in terms of its crunchiness. There was significant (P<0.05) variation in the packed bulk density (PBD) of the samples that ranged from 0.83 - 0.90 g/ml. This was in line with the report by Obinna-Echem *et al*. (2020) for cowpea-tigernut flours blends. High PBD would imply a nutrient dense flour and is good for food preparations. LGC is used to measure the ability of the protein to form a gel. Abu *et al*. (2005) suggests that a lower LGC indicates a better gelling capacity. There was no variation in the LGC of all the flour blends, implying that the tigernut flour inclusion had no significant effect on the gelling ability of wheat flour and can be used in food production.

Table 2: Water and Oil Absorption Capacity, Least Gelation Concentration, Loose and Packed Bulk Density of Wheat - Tigernut flour Blends

Sample	Water absorption capacity (g/g)*	Oil absorption capacity (g/g)*	Least gelation concentration (%)*	Loose bulk density (g/ml)*	Packed bulk density (g/ml)
A	1.34±0.30	1.35±0.23	0.20±0.00	0.45±0.01	0.86^{ab}±0.02
B	1.34±0.02	1.31±0.08	0.20±0.00	0.48±0.01	0.85^{ab}±0.04
C	1.14±0.04	1.40±0.03	0.20±0.00	0.46±0.01	0.84^{ab}±0.00
D	1.18±0.14	1.33±0.05	0.20±0.00	0.49±0.01	0.83^{b}±0.01
E	1.31±0.00	1.22±0.13	0.20±0.00	0.50±0.07	0.90^{a}±0.04

Values are means ± standard deviation of duplicate samples. Means on the same column that do not share same letter are significantly different (P<0.05)
**No significant (P<0.05) differences among the samples for Water absorption capacity, Oil absorption capacity, Least gelation concentration and Loose bulk density*
A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour

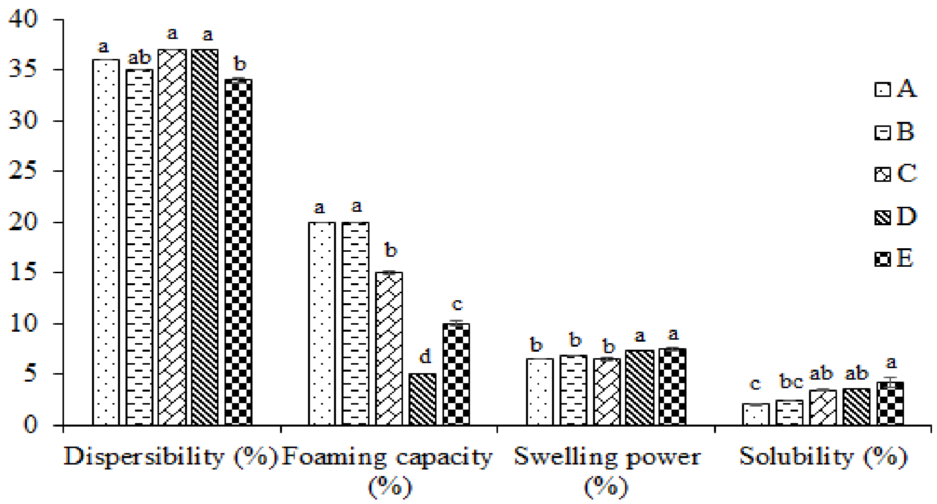

Figure 1: Dispersibility, foaming capacity, swelling power and solubility of the wheat-tigernut flour blends.
Bars and error bars represent mean and standard deviation of duplicate samples. Bars with the same letters for each parameter are not significantly (P>0.05) different.
A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour

Dispersibility shows the ability of the flour to reconstitute in water. Inclusion of tigernut flour significantly (P<0.05) increased the dispersibility of the wheat-tiger flour samples from 34-37%. These values are low compared to the values of 45 -51% reported for different cereal grains by Oluwole, *et al*. (2016) and samples with low dispersibility may form lumps during mixing which would require extra effort and time to delump. The high dispersibility as a result of tigernut flour incorporation would mean that the wheat-tigernut flour blends will give a better the reconstitution in water to give a fine and consistent paste. The swelling power and solubility of the samples ranged from 6.45-7.48% and 2.00-4.13% respectively. Sample A had significantly (P<0.05) the least values, and sample E the highest values. The inclusion of tigernut flour reduced the swelling power as well as the solubility of the samples. The swelling power and solubility obtained from this study were similar to Adeola *et al.* (2014) and Adepoju *et al.* (2014) who reported swelling power and solubility of 6.90 - 8.57% and 2.27 - 4.90% respectively for complementary food samples. Low swelling power and solubility may influence the rising of bakery products. Foaming capacity of the flour samples ranged from 5.00% (sample D) to 20.00% (samples A and B). Foaming capacity measures the amount of interfacial area created by protein during foaming (Zhu *et al*., 2017). The foaming capacity of wheat flour in this study (10.00%) is similar to 11.79 and 12.92% reported by Suresh and Samsher (2013) and Nawaza *et al*. (2015). Foaming capacity affects the consistency and appearance of foods. High foaming capacity implies a better continuous cohesion of the flour protein around air bubbles and this is very good for bakery products like cakes (Nawaza *et al*., 2015).

3.3 Proximate Composition and Energy Value of Wheat-Tigernut flour Blends

Proximate composition and energy value of wheat-tigernut flour blends is presented in Table 3. There was significant (P<0.05) decrease in moisture with increase in tigernut inclusion. The moisture content ranged from 5.55 - 8.79% for sample D and E respectively. Low moisture content indicates storage stability and reduced biochemical activities (Nesreen, 2020). The protein content of the flour blends decreased significantly (P<0.05) with the increase in substitution level of tigernut flour, and ranged from 9.28 - 18.36% with sample D recording significantly (P<0.05) the least value and E recorded the highest value. The decrease can be attributed to the fact that tigernut is a tuber that contains more of starch and low protein. Adebayo-Oyetor *et al*. (2017) reported 11% protein content of wheat flour substituted with 30% tigernut flour, and did not vary much from 10.24% of the same ratio reported here in sample C. Fat content of the samples ranged from 2.12% (sample E) to 10.91% (sample D). There was increase in the fat content of the samples with increase in substitution level of tigernut flour. This may be due to high amount of fat in tigernut as reported by Bamishaiye and Bamishaiye (2011). Ash content of the flours ranged from 1.79% for sample E to 2.01% for sample C. Tigernut flour inclusion increased the ash content of the wheat flour samples, indicating that the wheat-tigernut flour blends will have higher mineral content. This is in agreement with Mepba *et al.* (2007) who opined that the ash content is a rough estimate of the mineral contents of foods. There was significant (P<0.05) decrease in crude fibre content of the samples with the inclusion of tigernut flour. The values ranged from 1.31-4.17% with the significantly (P<0.05) lowest value recorded for sample A, while sample E recorded the highest value. Carbohydrate content of the samples ranged from 64.78-74.6%. Sample E had significantly (P<0.05) the least value while sample A had the highest value. Addition of tigernut flour increased the carbohydrate content of the wheat flour, though there was decrease with increase in the amount of tigernut added. Samples with higher proportions of tigernut flour recorded the lowest carbohydrate content among the tigernut flour substituted samples. Energy value of the flour samples varied significantly (P<0.05) from 351.69 Kcal/100g for sample E to 416.63 Kcal/100g for sample D. Inclusion of tigernut flour increased the energy value of the wheat flour samples and increased with increase in substitution level.

Table 3: Proximate Composition (%) and Energy values (Kcal/100g) of Wheat and Tigernut flour Blends

Sample	Moisture	Protein	Fat	Ash	Crude Fibre	Carbohydrate	Energy
A	$6.37^{b}\pm0.11$	$12.06^{b}\pm0.04$	$4.20^{cd}\pm0.19$	$2.00^{ab}\pm0.09$	$1.31^{b}\pm0.35$	$74.06^{a}\pm0.04$	$383.51^{c}\pm0.14$
B	$6.13^{bc}\pm0.04$	$10.94^{c}\pm0.13$	$6.87^{bc}\pm1.51$	$1.82^{ab}\pm0.02$	$2.06^{b}\pm0.42$	$72.20^{ab}\pm1.22$	$394.31^{bc}\pm8.14$
C	$5.90^{bc}\pm0.07$	$10.24^{d}\pm0.13$	$9.66^{ab}\pm0.57$	$2.01^{a}\pm0.07$	$1.76^{b}\pm0.28$	$70.43^{b}\pm0.16$	$405.32^{ab}\pm2.12$
D	$5.55^{c}\pm0.07$	$9.28^{e}\pm0.00$	$10.91^{a}\pm0.16$	$1.86^{ab}\pm0.00$	$2.07^{b}\pm0.23$	$70.34^{b}\pm0.14$	$416.63^{a}\pm0.90$
E	$8.79^{a}\pm0.33$	$18.36^{a}\pm0.00$	$2.12^{d}\pm0.00$	$1.79^{b}\pm0.01$	$4.17^{a}\pm0.07$	$64.78^{c}\pm0.27$	$351.69^{d}\pm1.14$

Values are means ± standard deviation of duplicate samples. Means on the same column that do not share same letter are significantly different (P<0.05)
A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour

3.4 Proximate Composition (%) and Energy Value (Kcal/100g) of *Chin-chin* produced from wheat and tigernut flour blends

The proximate and energy value of *chin-chin* produced with flour blends of tigernut and wheat are shown in Table 4. The proximate composition of the *chin-chin* was significantly (p<0.05) higher than those of their flour blends except for the carbohydrate content. This is indicative of the contribution of the ingredients used in the increment in the nutrient content of the *chin-chin*. The moisture content of the *chin-chin* samples ranged from 1.85% (sample E) to 8.64% (sample A).

The moisture content could be a function of the water and other wet ingredients added during the *chin-chin* production. The inclusion of tigernut flour led to increase in moisture content of the *chin-chin* sample and there was significant difference (p<0.05) between the samples. The moisture content of the *chin-chin* samples produced with composite flour however decreased with increase in tigernut flour inclusion. The moisture content of chin-chin produced with wheat flour in this study (1.85%) was lower than 4.85% reported by Deedam *et al.* (2020), and can be attributed to the thickness of the *chin-chin* dough (2 cm) used by the researches, against the 1 cm dough thickness used in this study. The moisture content of chin-chin produced with wheat and tigernut flour blends in this study (2.45-8.64%) compares with 4.17-6.80% reported by Akindele *et al.* (2017) for *chin-chin* enriched with pumpkin and Indian spinach vegetables, and 5.70-7.65% reported by Deedam *et al.* (2020) for *chin-chin* produced with wheat and soursop flour blends.

Protein content of the *chin-chin* samples varied significantly (P<0.05) from 10.06% for sample B to 16.18% for sample A. There was significant (P<0.05) difference between the control and the test samples. This result agrees with the report of 7.66 - 11.58% and 12.63 - 19.50% for wheat-tigernut and millet-wheat *chin-chin* respectively (Adebayo-Oyetor *et al*., 2017; Adegunwa *et al*., 2014). The fat content of the samples varied significantly (P<0.05) from 24.25% for sample A to 34.29% for sample C. These values are similar to 100% wheat flour *chin-chin* (33.31%) reported by Deedam *et al.* (2020). The high fat content of the *chin-chin* from this study is attributable partly to the some of the ingredients used and mostly to the frying oil. Ash content of the *chin-chin* samples ranged from 1.20 - 1.70% for sample E and B respectively. The inclusion of tigernut flour increased the ash content of the *chin-chin* samples. The ash content from this study was higher than 0.40-1.09% reported by Eke-Ejiofor and Beleya (2019) for *chin-chin* produced from high quality cassava flour and tiger nut residue flour blends. The ash content result obtained here indicates that *chin-chin* produced from wheat and tigernut flour blends would contribute mineral elements to the body, as ash content is a rough estimate of the mineral content of food Mepba *et al.*, 2007).

Crude fibre content of the *chin-chin* samples ranged from 15.30% for sample B to 27.42% for sample E. The substitution of wheat with tigernut flour led to a reduction in the crude fibre content of the *chin-chin* samples. There was significant difference (p<0.05) between the control and the substituted samples. The crude fibre content of the *chin-chin* samples here were similar to 11.08-12.95% reported by Eke-Ejiofor and Beleya (2019) for high quality cassava flour/tigernut residue *chin-chin*, and differs from 0.95-1.12% reported by Deedam *et al.* (2020) for *chin-chin* produced from wheat and soursop flour blends. Significant difference (P<0.05) existed between the carbohydrate content of the 100% wheat *chin-chin* and the substituted samples. Substitution of wheat with tigernut flour led to increase in the carbohydrate content of the *chin-chin* samples. The values ranged from 20.78-41.65 % for sample E and B respectively. These values were lower than those of their flour blends. The addition of other ingredients and the increase in fat content of the *chin-chin* could have led to this decrease. The energy value of the samples ranged from 418.03 kcal/100g for sample A to 493.27 kcal/100g for sample C. The energy value recorded here were higher than 393.34-401.68 kcal/100g reported by Deedam *et al.* (2020) for *chin-chin* produced with blends of wheat and soursop flours, but similar to the report of 448.25 - 461.02 kcal/100g by Ibidapo *et al.* (2017) for biscuits enriched with carrot flour.

For adult male and female weighing >50 kg the recommended protein requirement per body weight is 0.66 g (WHO/FAO/UNU, 2007). This implies that the protein content of the *chin-chin* will be able to meet 28-36% for the test samples and 56% for the 100% wheat flour chin-chin. Energy requirement of same adults involved in moderate activities is 212 and 183 KJ/kg body weight. Consumption of 100 g of the chin-chin will meet about 17 - 19 and 19 - 23 % of the energy requirement for male and female respectively.

Table 4. Proximate Composition (%) and Energy values (Kcal/100g) of Chin-chin Produced from Wheat and Tigernut flour Blends

Sample	Moisture	Protein	Fat	Ash	Crude Fiber	Carbohydrate	Energy
A	$8.64^{a}\pm0.07$	$16.18^{a}\pm0.00$	$24.25^{c}\pm0.07$	$1.35^{bc}\pm0.07$	$15.82^{b}\pm0.12$	$33.75^{c}\pm0.05$	$418.03^{b}\pm0.44$
B	$6.34^{b}\pm0.35$	$10.06^{d}\pm0.00$	$24.95^{c}\pm0.00$	$1.70^{a}\pm0.00$	$15.30^{bc}\pm0.14$	$41.65^{a}\pm0.22$	$431.39^{b}\pm0.85$
C	$3.25^{c}\pm0.07$	$10.10^{d}\pm0.06$	$34.29^{a}\pm0.53$	$1.64^{a}\pm0.06$	$14.65^{c}\pm0.44$	$36.05^{b}\pm0.38$	$493.27^{a}\pm6.55$
D	$2.45^{d}\pm0.70$	$15.75^{b}\pm0.00$	$28.21^{b}\pm0.09$	$1.54^{ab}\pm0.06$	$15.44^{bC}\pm0.18$	$36.61^{b}\pm0.05$	$480.40^{a}\pm24.7$
E	$1.85^{d}\pm0.07$	$14.87^{c}\pm0.00$	$33.86^{a}\pm0.09$	$1.20^{c}\pm0.00$	$27.42^{a}\pm0.09$	$20.78^{d}\pm0.06$	$447.45^{ab}\pm0.57$

Values are means ± standard deviation of duplicate samples. Means on the same column that do not share same letter are significantly different (P<0.05)
A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour

3.5 Sensory Attributes of Chin-chin produced from wheat and tigernut flour blends

The Assessors degree of likeness for the sensory attributes of the wheat-tgernut *chin-chin* is shown in Figure 2. The degree of likeness for Aroma ranged from 2.85-7.15 for sample E and B respectively. This average degree of likeness is from dislike very much to like moderately. The degree of likeness for appearance, colour, crunchiness, taste and overall acceptability were in the range of 3.55-7.85, 3.05-6.60, 3.40-7.10, 3.56-8.00 and 3.06-7.26 respectively. This means that the average degree of likeness is between dislike moderately and like moderately (Iwe, 2010). There was significant (P<0.05) variation in the degree of likeness of the 100% wheat flour *chin-chin* and the tigernut substituted *chin-chin*. The 100% wheat flour chin-chin (sample E) had the least degree of likeness for all attributes which did not differ significantly from that of sample D with 30% inclusion of tigernut flour. Sample A with 10% tigernut flour had significantly (P<0.05) the highest degree of likeness for colour, crunchiness, taste and overall acceptability while sample B with 20 % tigernut flour and sample C with 30% tigernut flour had the highest degree of likeness for aroma and appearance respectively. The average degree of likeness for the 10-30 % tigernut flour inclusion indicated higher likeness than the control and such substitution can be used in the production of chin-chin acceptable to the consumers.

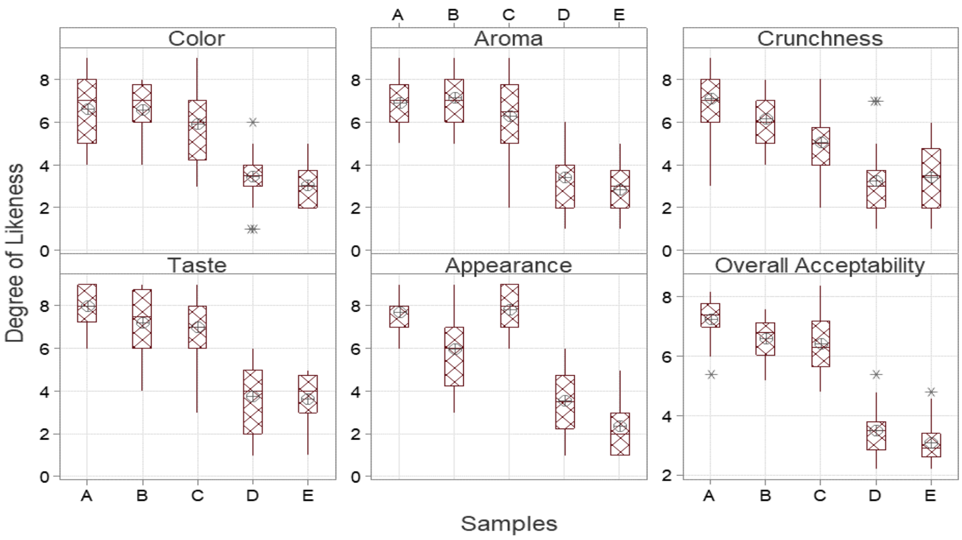

Figure 2: Box plot of the sensory attributes of wheat-tigernut flour chichin. Each box represents the interquartile range with the mean symbol at the centre.

A = 90% Wheat flour and 10% tigernut flour
B = 80% Wheat flour and 20% tigernut flour
C = 70% Wheat flour and 30% tigernut flour
D = 60% Wheat flour and 40% tigernut flour
E = 100% Wheat flour
Hedonic Scale
1 = dislike extremely, 2 = dislike very much, 3 = dislike slightly, 4 = dislike moderately, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = liked very much, 9 = liked extremely

4. Conclusion

This study revealed that the pH, TTA, viscosity, sugar, water and oil absorption capacity, bulk density, LGC, dispersibility, foaming capacity, swelling power and solubility of the wheat-tigernut flour were comparable with that of 100% wheat flour and the qualities are good for bakery products. The chin-chin produced from the flour blends were rich in fats, protein, carbohydrates and energy. The average degree of likeness for sample A with 10% tigernut inclusion was significantly (P<0.05) higher than others for colour, crunchiness, taste and overall acceptability followed by while sample B and C with 20 and 30% tigernut flour respectively. The addition of 10 – 20% tigernut flour to wheat flour in the production of *chin-chin* is recommended. This would add value to the use of tigernut and also aid in consumers deriving the many health benefits from tigernut in their snacks.

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Competing Interests

Authors declare that there are no competing interests exist.

Authors' Contributions

Author O-E PC, designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and edited the manuscript. Author AAO, managed the literature search and formatted the manuscript. ECC managed the analyses of the study, was involved in literature search and draft of the manuscript.

Consent (Where ever applicable)

Not applicable

Ethical Approval (Where ever applicable)

Not applicable

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