Comparative Analysis of the Proximate and Sensory Properties of Wheat-whole Tiger Nut Biscuits replaced with Avocado Paste

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ABSTRACT
Background: *Biscuits are dominantly produced from wheat flour and baking fat, two ingredients linked with celiac and cardiovascular diseases, hence the need to partially or completely replaced them.*
Objective: *This study investigated the effect of replacing fat with avocado paste on the proximate and sensory properties of wheat-tigernut biscuits.*
Materials and methods: *Whole tigernut was processed into flour and blended with wheat flour at three different levels; 10%, 20% and 30% weight basis into two parts. The first part of the composite (T10, T20, and T30) and control sample (%wheat flour: T00) were baked into biscuit using margarine, while in the second batch (AT10, AT20, and AT30), margarine was replaced with avocado paste (100%). Biscuit samples were evaluated for proximate and sensory properties. Data were subjected to Analysis of Variance at $p<0.05$.*
Results: *Proximate composition of the biscuit samples increased progressively with increasing substitution of wheat flour with whole tigernut flour from 0% to 30% for all samples. Biscuits baked with avocado had higher moisture, ash, crude protein, and comparative crude fibre content, but lower fat and carbohydrate compared to values obtained for biscuits baked with margarine. Sensory properties of biscuits baked with margarine were not adversely affected, while biscuits baked with avocado were acceptable up to 10% whole tigernut flour substitution.*
Conclusion: *Utilization of tigernut flour and avocado paste as substitute to wheat flour and fat, respectively, showed promising prospects and should be optimized and exploited as a healthier dietary source to enrich bakery products like biscuits in Nigeria.*

Keywords: Biscuits, tigernut, avocado, margarine, wheat

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INTRODUCTION

Biscuits are ready-to-eat, convenient and inexpensive food product (1) made from wheat flour, sugar, milk, fat, flavouring agents and other raising agents (2). They contain considerable amount of fats and carbohydrates, and are also good source of protein and minerals (3).

Consumers demand for convenient and nutritious food products with improved taste, safety (4) and good shelf life at ambient temperature (5) has renewed interests and attempts to improve the nutritional quality and functional properties of biscuits (6). Wheat flour has been the preferred staple ingredient in biscuit production over the years due to its protein content, which is not found in other grain flour, however, it lacks essential amino acids such as lysine, tryptophan and threonine (8). Enriching wheat flour with a wide variety of nutrient rich cereals, pulses, fruits like avocado pear and tubers (7) such as tiger nut will provide steps closer towards actualizing consumers demand.

Tiger nut (*Cyperus esculentus* L.) is an underutilized crop with a sweet and nutty taste (9). It is known as *Aya* in Hausa, *Ofio* in Yoruba, *Aki* in Igbo and *Shoho* in Tiv language (3). The tubers are edible and the flour can be used as composite in the production of confectioneries like high fibre biscuits due to the high dietary fibre content. The tuber contains 45.73% carbohydrate, 30.01% oil, 5.08% protein, 2.23% ash and 14.80% crude fiber (10). Tigernut flour has been demonstrated to be a rich source of quality oil and contains moderate amount of protein, carbohydrate, sugars, phosphorus and potassium (3). It is also an excellent source of some useful minerals such as iron and calcium which are essential for body growth and development (5).

Avocado (*Persea americana*) is known for its pleasing taste and predominance of lipids rich in monounsaturated fatty acids. It is a high caloric fruit and is rich in vitamns A and C (11), hence, may be a suitable fat substitute in baking.

Fat plays an important role in both taste and texture of baked products; therefore, choosing the appropriate fat substitute for a product or recipe is a critical step in replacing the fat (12). Bakery fats like margarine and butter contain about 80% fat. A large content in unsaturated fatty acids is one of the distinguishing characteristics of avocado (13). For this reason, the choice of avocado is due to the demand for health-promoting foods with nutritional relevance, in order to drift away from trans-fat consumption from baking margarine to healthier plant fat options from fruits like avocado in bakery products. The effect of fat replacement with healthier vegetable oils have shown promising improvement on biscuit quality as shown by some authors (14, 15, 16, 17). Again, the adoption of composite flour intended to replace wheat flour totally or partially in bakery and pastry products has been recommended in order to save money for the country, promote high yielding native plant species and provide better supply of protein for human nutrition. Therefore, the objective of this study was to adopt avocado pear as a fat replacer and evaluate proximate and sensory properties of biscuits produced from wheat and whole tiger nut composite flour.

MATERIALS AND METHODS

SOURCE OF RAW MATERIALS

Wheat flour- a product from the Nigeria Flour Mill Ltd, baking powder, eggs, sugar, margarine, salt (Dangote Nigeria Ltd) and avocado pears (Bacon variety) were purchased from commercial stockers at Ubani main market, Umuahia, Abia state. Fresh tigernut tubers (brown variety) were purchased from Ogbo-Hausa market, Owerri road, Umuahia, Abia state. All reagents used in this study were of analytical grade and were sourced from the Laboratory Department of Biochemistry, National Root Crops Research Institute, Umudike, Abia State, Nigeria.

Processing of tigernut tubers into whole tigernut flour

Fresh tiger nut tubers were sorted to remove extraneous substances like stones, pebbles and spoilt tubers before washing with potable tap water (18). The prepared tubers were dried in a hot air oven (Model no.SX3-4.5-15: made in China) at 60°C for 24 hours to a moisture content of 10%. The dried tubers were milled into powder using a commercial hammer mill. The subsequent flour was filled in transparent polythene and sealed air-tight for further analysis.

Avocado pear pulp extraction

Mature and ripe avocado fruits were washed with potable water and the pericarp and seed were removed with kitchen spoon. The pulp was then extracted into a thoroughly washed and dried container and mashed in a Sonik blender (Model no.SFP-2210; 220 V, 50 Hz, 450 W: made in China) to obtain smooth paste. The required sample needed for the production was deduced from the paste obtained.

Composite flour formulation

Two batches of composites of whole tigernut and wheat flours were formulated with the same ratios in each batch. The first and second batches contained 3 samples as follows; 90% wheat flour: 10% whole tigernut flour (T10), 80% wheat flour: 20% whole tigernut flour (T20) and 70% wheat flour: 30% whole tigernut flour (T30). The first batch of the composite (T10, T20, and T30) and the control sample (100% wheat flour; T00) were baked using margarine, while in the second batch (AT10, AT20, and AT30), margarine was completely replaced with mature and ripe avocado paste (100%).

Determination of functional properties of composite flour

The bulk density, water absorption and oil absorption capacities, emulsion capacity, foam capacity, swelling index, wettability and gelatinization temperature was determined following standard procedures (19).

Production of biscuit samples

Biscuits were produced using the rubbing-in method as described by (3) with slight modifications in the recipes which include introduction of liquid milk, avocado paste, whole tigernut flour and egg into the recipe. All the ingredients contained in the recipe were accurately weighed or measured as the case may be (Table 1). To the first batch of composite flour, the dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for about 3 minutes. Vegetable shortening (baking margarine) was added and mixed until uniform. Egg, milk and water were then added and the mixture kneaded. The batter was rolled and cut with a 50 mm diameter biscuit cutter. The biscuits were placed on greased baking trays, leaving 25 mm spaces in between and baked at 180°C for 10 minutes in the baking oven (put model of the oven). Following baking, the biscuits were cooled to ambient temperature, packed in an airtight plastic transparent containers and stored at 23°C prior to subsequent analysis and sensory evaluation. To the second batch of the composite flour, the same process was used in the production of biscuits as is the case with the first batch, however, the baking margarine was replaced with avocado paste in the samples. Pictorial representation of control and experimental biscuit samples are presented in Plates 1-7.

Proximate evaluation of biscuit samples

The moisture, ash, crude protein, crude fibre and crude fat were determined according to AOAC (20). Protein conversion factor of 6.25 was used to convert N content to crude protein, while carbohydrate was estimated by difference [i.e. 100% – protein (%) + fat (%) + crude fibre (%) +Ash (%)].

Sensory evaluation

A 25-man panelist conducted a descriptive sensory evaluation on the biscuit samples from different combinations. The panelists were semi-trained on the organoleptic and physical characteristics of a good biscuit, educated on what sensory evaluation is, the steps involved in the procedure and how to register their perceived characteristic using the 9-point hedonic scale, using standard procedures (21). Each sample was placed on white saucer, coded with random 3 or 4-digit numbers as the case may be and presented to the panelists for analysis. The biscuits were analyzed for appearance, texture, aroma, taste, mouth-feel and over-all acceptability, using 9-point hedonic scale with 1 for disliked extremely and 9 for liked extremely. Panelists were provided with distilled water to rinse mouth between tasting to avoid carry over taste. Biscuit samples that scored 5 and above (neither liked nor disliked to extremely liked) for overall acceptability were considered acceptable.

Statistical Analysis

Data obtained were subjected to descriptive statistics and means subjected to one-way analysis of variance (ANOVA). Statistical Package for Social Science Version 15.0. was used for data analysis and means were separated using Duncan's Multiple Range Test (DMRT with statistical significance accepted at $p < 0.05$.

RESULTS

Results of functional properties of composite flour

Table 2 shows that substitution of wheat flour with different levels of whole tigernut flour significantly ($p<0.05$) affected the functional properties of the composite flour. There was significant ($p<0.05$) difference in the functional properties of the flour samples. These variations were expected since the wheat and tigernut have variable macronutrient and micronutrient composition. The control sample (T00; 100% wheat flour), had relatively higher bulk density (BD) (0.78 g/ml), water absorption capacity (1.88 g/ml), gelatinization temperature (GT) (68.50 °C) and wettability (65.00 s) than whole tigernut flour supplemented wheat flours. T10 and T20 did not differ significantly ($p< 0.05$) from each other with respect to bulk density and emulsion capacity. T00 and T10 did not differ from each other with respect to water absorption capacity while T30 and T40 did not differ with respect to water absorption capacity. The functional properties ranged from 0.65 to 0.78 g/ml for bulk density, 1.53 to 1.78 g/ml for water absorption capacity, 1.29 to 1.44 g/ml for oil absorption capacity, 18.85 to 23.60% for emulsion capacity, 19.51 to 22.75 g/ml for foam capacity, 2.14 to 2.47% for swelling capacity, 50.50 to 65.00 s for wettability and 64.50 to 68.50 °C for gelatinization temperature.

Table 1: Biscuits recipe with different levels (%) of wheat-whole tigernut flour and avocado paste substitution.

Ingredients (%)	T00	T10	T20	T30	AT10	AT20	AT30
Wheat flour (g)	500	450	400	350	450	400	350
Whole-tigernut flour (g)	0	50	100	150	50	100	150
Margarine (g)	100	100	100	100	0	0	0
Avocado paste (g)	0	0	0	0	100	100	100
Sugar (g)	250	250	250	250	250	250	250
Baking powder (g)	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Salt (g)	2	2	2	2	2	2	2
Egg (g)	60	60	60	60	60	60	60
Milk (ml)	75	75	75	75	75	75	75
Water (ml)	75	75	75	75	75	75	75

T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30= 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

T00 (0% whole tigernut flour)

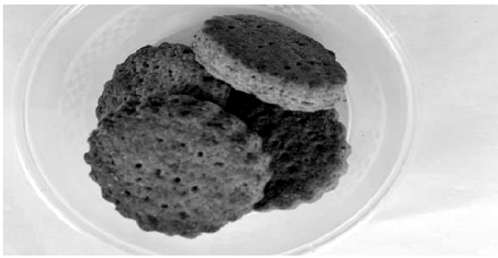

Plate 2: T10 (10% whole tigernut flour)

Plate 3: T20 (20% whole tigernut flour)

Plate 4: T30 (30% whole tigernut flour)

Plate 5: AT1 0 (10% whole tigernut flour with avocado paste)

Plate 6: AT2 0 (20% whole tigernut flour with avocado paste)

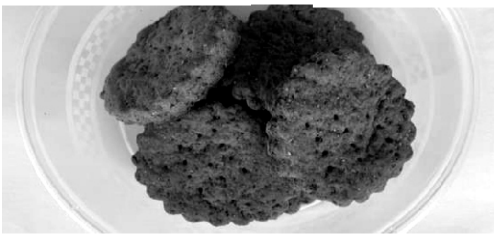

Plate 7: AT30 (30% whole tigernut flour with avocado paste)

Table 2: Functional properties of wheat-whole tigernut composite flour blends.

Samples	Bulk density (g/ml)	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Emulsion capacity (%)	Foam capacity (%)	Swelling index (%)	Wettability (s)	Gelatinization temperature (°C)
T00	$0.78^{a}\pm0.01$	$1.53^{c}\pm0.02$	$1.29^{e}\pm0.01$	$18.85^{d}\pm0.78$	$19.51^{e}\pm0.13$	$2.14^{e}\pm0.03$	$65.00^{a}\pm0.01$	$64.50^{e}\pm0.01$
T10	$0.68^{b}\pm0.01$	$1.57^{c}\pm0.01$	$1.35^{d}\pm0.01$	$20.75^{c}\pm0.18$	$21.54^{d}\pm0.08$	$2.19^{d}\pm0.01$	$58.00^{b}\pm0.01$	$66.00^{d}\pm0.01$
T20	$0.68^{b}\pm0.01$	$1.74^{b}\pm0.02$	$1.39^{c}\pm0.01$	$21.70^{c}\pm0.14$	$21.87^{c}\pm0.04$	$2.38^{c}\pm0.03$	$54.00^{c}\pm0.01$	$67.00^{c}\pm0.01$
T30	$0.65^{c}\pm0.01$	$1.78^{a}\pm0.04$	$1.44^{b}\pm0.01$	$23.60^{b}\pm0.14$	$22.75^{b}\pm0.07$	$2.47^{b}\pm0.02$	$50.50^{d}\pm0.71$	$68.50^{b}\pm0.01$

a-e: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($P<0.05$).
T00 = 100%
wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30= 70% wheat flour:
30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

Table 3: Proximate composition of biscuits samples from wheat - whole tigernut composite (%).

Samples	Moisture content	Ash content	Crude protein content	Crude fibre content	Crude fat content	Carbohydrate content
T00	$6.64^{d}\pm0.08$	$1.75^{f}\pm0.01$	$8.22^{f}\pm0.03$	$1.63^{e}\pm0.01$	$13.22^{e}\pm0.03$	$68.54^{a}\pm0.14$
T10	$4.81^{e}\pm0.01$	$3.85^{d}\pm0.01$	$8.46^{e}\pm0.06$	$5.69^{d}\pm0.01$	$16.82^{c}\pm0.01$	$66.44^{b}\pm0.01$
T20	$7.51^{c}\pm0.01$	$3.93^{b}\pm0.01$	$8.87^{c}\pm0.04$	$6.77^{c}\pm0.02$	$17.42^{b}\pm0.01$	$62.52^{d}\pm0.07$
T30	$4.67^{e}\pm0.05$	$3.95^{b}\pm0.01$	$9.18^{b}\pm0.03$	$6.88^{a}\pm0.02$	$18.37^{a}\pm0.02$	$63.97^{c}\pm0.12$
AT10	$11.90^{a}\pm0.01$	$3.89^{c}\pm0.01$	$9.15^{b}\pm0.01$	$6.81^{b}\pm0.02$	$16.77^{c}\pm0.04$	$58.48^{f}\pm0.02$
AT20	$10.47^{b}\pm0.01$	$3.77^{e}\pm0.01$	$8.65^{d}\pm0.01$	$6.73^{cd}\pm0.01$	$15.73^{d}\pm0.01$	$61.67^{e}\pm0.03$
AT30	$10.59^{b}\pm0.35$	$4.15^{a}\pm0.02$	$9.41^{a}\pm0.01$	$6.87^{a}\pm0.01$	$17.40^{b}\pm0.01$	$58.57^{f}\pm0.42$

a-f: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscript are significantly different ($P<0.05$). T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30= 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

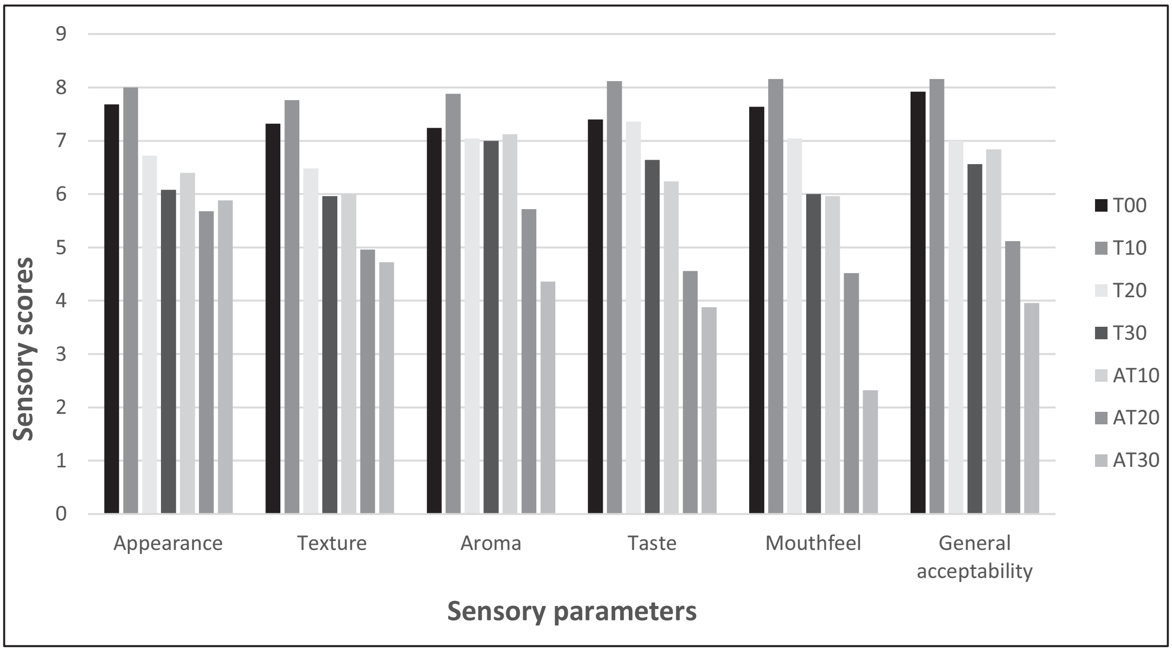

Figure 1: Sensory characteristics of biscuits samples influenced by whole tigernut flour inclusion and avocado paste. T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30= 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

Results of proximate composition of composite biscuits

Table 3 shows the proximate composition of the biscuit samples with different levels of whole tigernut flour and fat substitute (avocado paste). There was significant ($p<0.05$) difference among the samples. Control samples had lower ash (1.75%), crude protein (8.22%), crude fibre (1.63%), crude fat (13.22%) and higher carbohydrate (68.54%) contents compared to the experimental samples. The moisture, ash, crude protein, crude fibre, crude fat and carbohydrate content for samples containing avocado paste as the shortening agent ranged from 10.47 to 11.90%, 3.77 to 4.15%, 8.65 to 9.41%, 6.73 to 6.87%, 15.73 to 17.40% and 58.48 to 61.67% respectively, while those containing margarine ranged from 4.67 to 7.51%, 3.85 to 3.95%, 8.46 to 9.18%, 5.69 to 6.88%, 16.82 to 18.37% and 62.52 to 66.44%, respectively.

RESULTS OF SENSORY PROPERTIES

Figure 1 shows sensory scores of the biscuits by the panelists. The scores for appearance, texture, aroma, taste, mouthfeel and general acceptability ranged from 5.88 to 7.68, 4.72 to 7.32, 4.36 to 7.24, 3.88 to 7.48, 2.32 to 7.64 and 3.96 to 7.92, respectively. Increasing substitution of whole tigernut flour from 10% to 30% significantly ($p<0.05$) reduced the scores for all biscuits sensory attributes. Except for T10 (10% whole tigernut flour substitution), all the experimental biscuits had sensory scores significantly ($p<0.05$) lower than the control sample. AT30 had the lowest sensory scores with respect to texture, aroma, taste, mouthfeel and general acceptability compared to other samples followed by At20.

DISCUSSION

Functional properties of composite flours

Substitution of wheat flour with different levels of whole tigernut flour significantly ($p< 0.05$) affected the functional properties of the composite flour (Table 2). Water absorption capacity, oil absorption capacity, emulsion capacity, foam capacity, swelling index and gelatinization temperature increased with increasing proportion of whole tigernut flour from 0% to 30% while bulk density and wettability decreased likewise. Bulk density (BD) is influenced by the structure of the starch polymers. Decreasing BD with increasing substitution of whole tigernut flour could be attributed to increasing concentration of loose structure of starch polymers (22). Water absorption capacity (WAC) is an important property in food. The ability of protein in flours to bind water is as a result of its water absorption capacity (23). Increasing WAC in the composite flours may be attributed to increased amount and nature of hydrophilic constituents (24) as whole tigernut flour substitution increases. Butt and Batool (25) reported that increased concentration of protein content, degree of association and conformational characteristics positively influences the WAC of flours. Oil absorption capacity and emulsifying capacity is an important parameter of flour used in baking (26). Higher oil absorption capacity of composite flours may be influenced by the Lipophilic nature of whole tigernut flour granules and indicate desirable flavour retention ability and palatability (27). Foam capacity (FC) is assumed to be dependent on the configuration of protein molecules. Flexible proteins have good foaming capacity, but a highly ordered globular molecule gives low foaming ability (28). Whole tigernut flour may have possessed flexible proteins, hence the increase in FC as whole tigernut flour substitution increases. Swelling index is a measure of hydration capacity which defines the wettability of flour samples. The higher the swelling index, the lower the wetting time (29). As whole tigernut flour substitution increased from 0 - 30%, swelling index of the composite flours increased, while wetting time decreases which may be due to increased hydrophilic sites. Gelatinization temperature (GT) increased as whole tigernut flour substitution increases, however, the control sample (TOO) gelatinized at a lower temperature. High gelatinization temperature of composite flours (0% - 30%) suggests starch dilution (30), hence, requiring higher temperature to gelatinize.

Proximate composition of biscuit samples

Ash, crude protein, crude fibre and fat contents of the biscuit samples increased progressively with increasing substitution of wheat flour with whole tigernut flour from 0% to 30% for all samples (Table 2). However, biscuits baked with fat substitute (avocado paste) had higher moisture, ash, crude protein contents, comparative crude fibre content, but lower fat and carbohydrate contents compared to the values obtained for biscuits baked with margarine. Moisture content of this study was lower than 11.13% to 14.60% reported by (17), but corresponds with 5.56 to 11.39% reported by (14) on cookies partially substituted with avocado pear and margarine. Higher moisture content in biscuit samples baked with avocado paste can be attributed to the high water content in the avocado fruit prior to addition, which consequently, influence the moisture rise, suggesting lower shelf stability. Ash content was higher than 1.40 to 2.09%, 1.37 to 1.78% and 2.67 to 3.01% reported by (16), (14) and (15), respectively. Increasing ash content implies increasing mineral content with increasing substitution of wheat flour with whole tigernut flour. Tigernut has been reported to be high in some important minerals such as iron and calcium (18), which may have contributed to the increase. Protein corresponds with 8.61 to 9.52% reported by (5) but lower than 10.09 to 14.05% reported by (31). Higher protein content of the composite biscuits suggests valuable contribution in combating protein energy malnutrition, especially for low income earners. More so, higher protein in composite biscuits can be attributed to tigernut flour which has been reported to contain over 5% protein (3). Crude fibre was higher than 2.06 to 4.01%, 0.29 to 0.54% and 2.11 to 2.71% reported by (32), (16) and (5), respectively on biscuits produced from different food sources. The composite biscuits had significantly higher fibre contents than the control sample. Fibre offers variety of health benefits. For instance, it is essential in reducing the risk of chronic diseases such as diabetes, obesity, cardiovascular diseases and diverticulitis, helping in bowel movement, lowering blood cholesterol, and reducing the risk of colon cancer (33). The higher fat content in biscuits baked with margarine might be due to the presence of concentrated fat resulting from hydrogenation. Notwithstanding, presence of appreciable fat in biscuit samples baked with avocado paste suggests possible presence of fat-soluble vitamins (A, D, E and K). However, higher fat in biscuits containing margarine as a shortening agent might affect the product keeping quality since fats are prone to oxidative rancidity. Some authors (14), (17) and (5) reported corresponding fat levels of 9.14 to 18.80% and 16.00 to 18.03%, respectively on cookies samples. Reduced carbohydrate content in the composite samples may be due to starch reduction with concurrent increase in ash, fat, protein. However, the carbohydrate content in the biscuits are considerably high and may be good source of energy for the body.

Sensory characteristics of biscuit samples

Sensory score for each parameter decreased progressively as the level of substitution with tigernut increases (Figure 1), and this is similar to observations of another author (17). Biscuits containing avocado had lower sensory scores than those baked with margarine, indicating less sensory preference. All biscuit samples baked with margarine were acceptable to the panelist, therefore, scored more than 5.0 on the average on the 9-point hedonic scale. In comparison to biscuits containing avocado paste as the shortening agent, the texture, taste and mouthfeel, especially of AT20 and AT30 were not acceptable by the panelists, which could be due to the high moisture imparted by avocado paste resulting to wet and non-crispiness of biscuits. However, the sensory scores for AT10 was acceptable when assessed for all sensory parameters. Generally, among the samples, T10 (10% whole tigernut flour substitution) was most acceptable, followed by the control samples and was subsequently followed by the experimental samples in their order of increasing whole tigernut flour substitution. Hence, biscuit samples produced from 90% wheat flour and 10% whole tigernut flour (T10) was rated highest (8.16) among the samples with respect to general acceptability and was liked very much. The preference for T10 could be attributed to moderate flavour imparted by the protein and oil rich properties of tigernut and avocado, respectively without losing the conventional properties for which biscuits are known for. The scores reported by (17) for appearance (6.95 to 8.05) and texture (6.90 to 7.50) for cookies corresponds with the scores obtained in this study, however, the taste (6.65 to 7.85) and aroma (6.95

to 7.95) were higher in their study. Another study (14) reported lower scores for taste (6.93 to 7.93), aroma (6.4 to 7.26) and general acceptability (6.66 to 7.33) for cookies compared to results of this study.

CONCLUSION

Substitution of wheat flour with whole tigernut flour up to 30% for biscuit production improved the proximate composition of biscuits. Complete replacement of margarine with avocado paste as a fat replacer did not impart negatively on the nutrient content of the biscuit samples. The sensory properties and the overall acceptability of composite biscuits baked with avocado paste was acceptable up to 10% whole tigernut flour substitution, but composite biscuits baked with margarine was acceptable up 30% whole tigernut flour substitution. Whole tigernut flour and avocado fruit should therefore be considered as a dietary source to enrich bakery products like biscuits in the country with the intent of developing healthier products.

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