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QUALITY EVALUATION OF COOKIES PRODUCED FROM COMPOSITE FLOUR OF WHEAT AND TIGERNUT RESIDUE

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Abstract

This study was carried out to determine the quality properties of cookies produced from blends of wheat flour and tigernut residue flours. The fresh tigernuts were selected, washed, crushed and the milk was extracted. The residue remaining after milk extraction was dried, milled into flour and then sieved. Composite flours were formulated by blending wheat flour with the tigernut residue flour in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 and were labeled as SWT, SWU, SWV, SWW, SWX and SWY respectively. These composite flours were used to produce cookies which were subjected to sensory evaluation using a 9 point Hedonic Scale. The results revealed mean scores ranging from 6.90 – 8.70 for colour, 6.50 – 8.60 for texture, 6.50 – 8.70 for taste, 6.60 – 8.60 for flavour and 6.60 – 9.00 for overall acceptability indicating that all the samples were generally liked. However, the most preferred sample which were SWT, SWU and SWV which had overall acceptability scores of 9.00, 8.40 and 7.90 respectively were further analyzed for their proximate composition using standard analytical methods. The results obtained were 3.13 – 3.58 % for moisture, 14.45 – 15.61 % for crude protein, 6.17 – 7.37 % for crude fat, 0.00 – 0.63 % for crude fibre, 0.57 – 1.50 % for ash and 73.27 – 74.29 % for carbohydrate content. This study concludes that tigernut residue flours could therefore be a viable substitute for wheat flour; this will help to reduce the huge amount of money spent in importation of wheat flour.

Keywords: Tigernut residue, composite flour, cookies.

Introduction

Cookies are nutritive snacks produced from unpalatable dough that is transformed in appetizing product through the application of heat in an oven (Adeyanju *et al.,* 2021). They are ready-to-eat convenient and inexpensive food product containing digestive and dietary properties of vital importance (Eke-Ejiofor, 2013). Durojaiye *et al.* (2018) stated that the principal ingredients for cookie formulation include wheat flour, fat, sugar and water however; other ingredients such as milk, salt, flavouring agent, spices and aerating agent may be added. Cookies are rich source of fats and carbohydrates (calories), hence are energy giving food and they are also a good source of protein, fibre, B-vitamins and minerals depending on the ingredients used (Alebiosu *et al.,* 2020). Cookies are widely consumed in many developing countries. They are usually affordable and consumed by all age groups (Kiin-Kabari *et al.,* 2021). In many parts of Sub-Sahara Africa and most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products especially cookies and bread (Adebowale *et al.,* 2012). Hence, a great need to harness our native agricultural product and diversify their uses to support this increasing population and the economy at large.

Wheat flour has been solely used to produce baked and deep fat fried 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; however, local climatic conditions in tropical countries such as Nigeria are not suitable for profitable wheat production (Adelekan *et al.,* 2019). In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals, root and tuber crops available for domestic use. Recently, government has collaborated with the research institutes to encourage the use of composite flours in the production of food products such as cookies, bread etc. Several studies have reported the use of composite flour in production of pastry products (Akujobi, 2018; Senya *et al.,* 2021). All these efforts were aimed at improving the nutritional values of the pastry products and also to enhance crop utilization. Hence, supplementation of wheat flour with inexpensive staples, from other cereals, legumes, roots and tubers will help, in improving the nutritional quality of wheat products (Oke *et al.*, 2017).

Tigernut (*Cyperus esculentus*) is underutilized crop of the family *Cyperaceae* which produces tubers that are somewhat spherical (Eke-Ejiofor and Allen, 2019). It is known in Nigeria as *aya* in Hausa, *ofio* in Yoruba and *akihausa* in Igbo (Obinna-Echem and Robinson, 2019). The nut is rich in energy content (starch, fat, sugars and protein), mineral (phosphorus, potassium) and vitamins E and C (Ayo *et al.,* 2018; Obinna-Echem *et al.,* 2020). Tigernut contain fairly high content of fibre and arginine (2-Amino-5-guanidinopentanoic Acid) a precursor of nitric oxide which causes blood vessels to open wider for improved blood flow, liberation of the hormones that produce the insulin that could help in immediate decomposition of sugar in the system, hence making it a good meal for diabetes and prevention and treatment of many diseases including colon cancer, coronary heart diseases, obesity, diabetes and gastrointestinal disorders (Adejuyitan, 2011). Tigernuts tubers can be processed into varieties of products such as vegetable milk, yoghurt and could be a good alternative to many other flours like wheat flour, as it is gluten free and good for people who cannot take gluten in their diets. It is also used in the confectionery industry. It is considered a good flour or additive for the bakery industry, since its natural sugar content is fairly high, avoiding the necessity of adding too much extra sugar. The residue remaining after tigernut milk extraction has also been processed into flour and used in bakery products (Akajiaku *et al.,* 2018; Ayo *et al.,* 2018; Idowu *et al.,* 2019; Senya *et al.,* 2021).

Wheat flour is major source of flour for pastry products such as biscuits, bread, cookies, cakes, buns, doughnuts etc. Wheat flour as the major ingredient has dominated other potential sources of flour for bakery products. However, the high cost of wheat flour has led to a rise in the cost of bakery products in Nigeria and indeed other developing countries of the world. Also, the ban on importation of wheat into the country has contributed immensely to the present high cost of bakery and confectionery products. This has resulted in the need to source for locally available and underutilized crops such as tigernut in the production of flours to be used as a substitute for wheat in manufacturing of bakery products such as cookies. The production of bakery products from composite flours of wheat and tigernut residue will not only increase varieties in the markets, but also improve the nutritional value of the products and limit the problem of waste management associated with tigernut milk processing. It is in view of this that the present study seeks to evaluate the feasibility of developing acceptable and nutritionally improved cookies from composite flours of wheat and tigernut residue.

Aim and Objectives of the Study

This study is aimed at evaluating the quality properties of cookies produced from composite flours of wheat and tigernut residue.

MATERIALS AND METHODS

Source of Material

Tigernut tubers, all purpose wheat flour and other baking materials such as butter, sugar, eggs, milk powder and salt were purchased from Eke market, Ekwuluobia, Anambra State. All chemicals used were of analytical grade.

Sample Preparation

Preparation of Tigernut Residue Flour

Tigernut residue flour was prepared using the method described in the study of Senya *et al.* (2021). Tigernut tubers were sorted to remove imperfect seeds and carefully washed. Two (2kg) kilograms freshly washed tigernut seeds were crushed, blended and milk extracted leaving the residue. The residue was dried in a cabinet dryer at 60^{o}C for 24 hours. Dried tigernut residue was milled into flour. The flour was sieved to obtain flour of uniform particle size. The tigernut residue flour was stored in a plastic air-tight container with lid at room temperature for further usage.

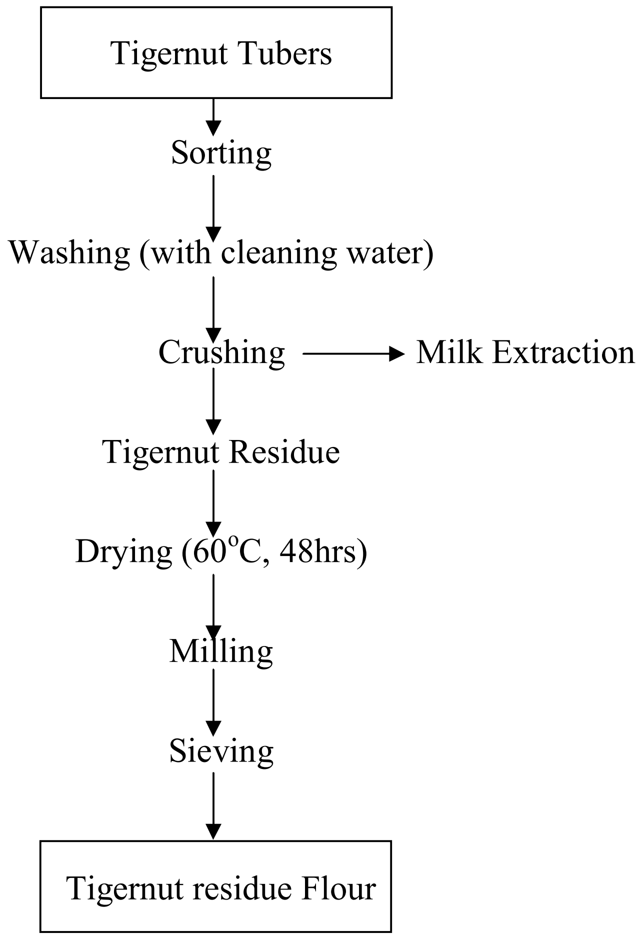

Fig. 1: Flow chart for the processing of tigernut residue flour
Source: Senya *et al.* (2021)

Formulation of Composite Flour

The composite flours for the production of both cookies were formulated as shown in the Table 1. Two hundred gram (200g) of the composite flours was used to produce the cookie samples to generate a total of six samples. One sample containing 100% wheat flour served as the control for the cookies. All samples were subjected to proximate and sensory analysis and the results generated were subjected to statistical analysis using version 25 of SPSS software.

Table 1: Formulation of Composite Flour

S/N	Wheat Flour	Tigernut Residue Flour
1.	100	0
2.	90	10
3.	80	20
4.	70	30
5.	60	40
6	50	50

Production of Cookies

The method described by Bello *et al.* (2020) was adopted in the production of cookies. Sugar, and margarine were accurately weighed, mixed in a stainless bowl and creamed until the mixture became light and fluffy. Milk powder was added to the cream while still mixing, allowed to mix for 20 minutes after which composite flour, baking powder, salt were gently poured into the mixture to obtain the dough. The dough was kneaded using a wooden rolling pin, on a flat-smooth board with intermittent sprinkling of flour to ease the kneading operation. Dough samples for biscuits were cut into shapes using a cutter and then placed on already oiled flat baking trays. The dough was baked at 250 ºC for 20 minutes in an oven until they are light brown in colour. Cookies after baking were allowed to cool for about 30 minutes and stored in airtight plastics containers for further analysis.

Creaming of Sugar and Margarine

↓

Addition of Milk Powder

↓

Addition of Composite Flour, Baking Powder and Salt

↓

Mixing

↓

Kneading

↓

Cutting and Shaping

↓

Baking (250^0C, 20min)

↓

Cooling

↓

Packaging

↓

Cookies

Fig. 2: Flow chart for the production of cookies.

Source: Bello *et al.* (2020)

Determination of Proximate Analysis

The proximate composition of the samples was determined by the standard methods described by the AOAC (2012) while carbohydrate content was determined by difference.

Moisture Content Determination

Five grams (5g) of the sample was weighed into a previously weighed moisture can. The sample in the can was dried in the moisture extractor at 105^oC for 3 hours. It was cooled in a dessicator and weighed. It was returned to the oven for further drying. Drying, cooling and weighing was done repeatedly at an hour interval until there was no further diminutions in the weight (i.e. a constant weight was obtained). The weight of moisture loss was calculated and expressed as a percentage of the weight of sample analyzed.

Calculation:

$$\% \text{ moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\%$$

Where,

W_1 = Weight of empty can

W_2 = Weight of empty can + sample before drying

W_3 = Weight of can + sample dried to a constant weight

Ash Content Determination

Clean dried crucibles were weighed on an electronic balance and 10g of sample weighed into the crucibles. The samples were dried in the moisture extraction oven until constant weights was obtained. Then, the sample was burnt to ashes in a muffle furnace at 550^{O}C. When completely ashed, it was cooled in a desiccator and weighed. The weight of ash obtained was calculated by difference and expressed as a percentage of the weight of sample analyzed.

$$\% \text{ Ash content} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100\%$$

Where,

W_1 = weight of empty crucible

W_2 = weight of crucible + Ash

Crude Fibre Determination

Two grams of the sample was boiled in 150mls of 1.25% H_2SO_4 solution for 30 minutes under some conditions. After washing in several portion of hot water, the sample was allowed to drain and dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105^{0}C to a constant weight. It was thereafter taken to a muffle furnace where it was burnt until only ash was left of it by difference; the weight of fiber was obtained and expressed as a percentage of weight of sample analyzed. It was given by the formula below:

Calculation:

$$\% \text{ crude fibre} = \frac{W_2 - W_3}{\text{Weight of sample}} \times 100\%$$

Where,

W_2 = weight of crucible + sample after boiling, washing and drying.

W_3 = weight of crucible + sample ashing.

Fat Determination

Ten grams (10g) of the sample was weighed into a thimble carefully and put in the sample holder of the soxhlet extraction apparatus. A clean dried and weighed soxhlet extraction flask was filled with 250ml of N hexane and the whole apparatus was assembled together, and the flask placed on the heating mantle and heated at 68^{o}C. The fat was extracted for three hours. The drying, cooling and re-weighing of the sample was repeated until a constant weight is obtained. The percentage fat contained was determined thus;

Calculation:

$$\% \text{ fat} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\%$$

Where,

W_1 = weight of empty filter paper

W_2 = Weight of paper + sample before defatting

W_3 = weight of paper + sample after defatting

Crude Protein Determination

This was done according to the method described by AOAC (2012). The total nitrogen was determined and multiplied with factor 6.25 to obtain the protein content. Half gram (0.5g) of the sample was mixed with 10ml of concentrated H_2SO_4 in a digestion flask. A tablet of selenium catalyst was added to it before it was heated under a fume cupboard until a clear solution was obtained (i.e. the digest). The digest was diluted to 100ml in a volumetric flask and used for the analysis. 10ml of the digest was mixed with equal volume of 45% NaOH solution in a Kjeldahl distillation into 10ml of 4% buric acid containing three drops of mixed indicator (bromocressol green/methyl red). A total of 50ml of distillates was collected and titrated against 0.02N EDTA from green to a deep red end point. A reagent blank was also digested, distilled and titrated. The nitrogen and protein content was calculated using the formula below:

$$\% \text{ protein} = \% N_2 \times 6.25$$

$$\% N_2 = \frac{100}{10} \times \frac{N \times 14}{1000} \times \frac{Vt}{Va}\ \text{T-B}$$

Where,
W = Weight of sample (0.5g)
Vt = Total digest volume (100ml)
Va = Volume of digest analysed (10ml)
T = Sample titre value
B = Blank titre value

Carbohydrate Determination

Carbohydrate content was by difference. It was calculated using the formula below:
% carbohydrate = 100 - % (moisture + crude protein + ash + crude fibre + crude fat).

Sensory Evaluation

A semi-trained panel of 20 judges made up of male and female staff and students of the Department of Food Technology, Federal Polytechnic Oko was used. The panelists were educated on the respective descriptive terms of the sensory scales and requested to evaluate the various cookies samples for taste, appearance, texture, aroma and overall acceptability using a 9-point Hedonic scale, where 9 was equivalent to like extremely and 1 meant dislike extremely. Presentation of coded samples was done randomly and portable water was provided for rinsing of mouth in between the respective evaluations.

Statistical Analysis

Data generated from the respective analyses were compiled appropriately and subjected to Analysis of Variance. All other data had the means separated using the Duncan Multiple Range test (Statistical Package for Social Science, version 25.0).

Results and Discussion

Table 2: Sensory qualities of cookies produced from blends of wheat flour and tigernut residue flour.

Samples	Colour	Texture	Taste	Flavour	Overall Acceptability
SWT	8.70^{a}±0.48	8.60^{a}±0.52	8.70^{a}±0.48	8.60^{a}±0.52	9.00^{a}±0.00
SWU	7.80^{ab}±0.79	7.50^{bc}±0.97	7.80^{ab}±1.40	7.90^{ab}±0.88	8.40^{ab}±0.70
SWV	7.30^{b}±0.67	7.60^{b}±0.70	7.60^{abc}±0.70	7.30^{b}±0.95	7.90^{bc}±0.57
SWW	6.90^{b}±1.85	6.50^{c}±1.35	6.60^{c}±1.77	6.60^{c}±1.35	7.10^{cd}±1.59
SWX	7.00^{b}±1.25	6.60^{bc}±1.65	6.50^{c}±1.17	6.80^{c}±1.14	7.00^{cd}±1.15
SWY	7.10^{b}±0.88	7.30^{bc}±0.82	6.80^{bc}±1.03	6.90^{bc}±1.10	6.60^{d}±1.17

*Values are means ± standard deviations of sensory evaluation. Means with the different superscripts in the same column are significantly different ($p < 0.05$).

Key:
SWT: 100:0 Wheat-Tigernut Residue Cookies.
SWU: 90:10 Wheat-Tigernut Residue Cookies.
SWV: 80:20 Wheat-Tigernut Residue Cookies.
SWW: 70:30 Wheat-Tigernut Residue Cookies.
SWX: 60:40 Wheat-Tigernut Residue Cookies.
SWY: 50:40 Wheat-Tigernut Residue Cookies.

Table 3: Proximate composition of selected cookies produced from blends of wheat flour and tigernut residue flour.

Samples	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)	Carbohydrates (%)
SWT	3.58^{a}±0.54	15.61^{a}±0.00	6.27^{a}±0.15	0.00^{b}±0.00	1.29^{b}±0.01	73.27^{a}±0.70
SWU	3.13^{a}±0.06	14.75^{a}±1.22	6.17^{a}±0.56	0.18^{b}±0.04	1.50^{a}±0.00	74.29^{a}±1.75
SWV	3.44^{a}±0.48	14.56^{a}±0.95	7.37^{a}±0.32	0.63^{a}±0.18	0.57^{c}±0.04	73.44^{a}±1.97

*Values are means ± standard deviations of triplicate determination. Means with the different superscripts in the same column are significantly different ($p < 0.05$).

Key:
SWT: 100:0 Wheat-Tigernut Residue Cookies.
SWU: 90:10 Wheat-Tigernut Residue Cookies.
SWV: 80:20 Wheat-Tigernut Residue Cookies.

Sensory Qualities of Wheat-Tigernut Residue Cookies

The results for the sensory evaluation of cookies produced from composite flours of wheat and tigernut residue are presented in Table 2. With respect to colour, the cookies samples had mean score ranging from 6.90 – 8.70 with sample SWW (70:30 wheat-tigernut residue cookies) having the least score while sample SWT (100:0 wheat-tigernut residue cookies) had the highest score. The results showed that the colour of sample SWT significantly differed ($p < 0.05$) from the rest of the samples. However, no significant differences ($p > 0.05$) existed in the colour of all the composite samples. All the samples were rated above approximately 7.00 indicating that they were generally liked. The panelists liked the brown colour of the cookies samples which may have resulted from Millard resulting from the presence of reducing sugars, proteins and amino acids and caramelization due to the effect of severe heating during processing (Nwatum *et al.,* 2020). Similar observation were made by Eke-Ejiofor and Deedam (2015) who reported mean values (3.35 – 4.15; on 5-point scale) which were above average for the colour of biscuits produced from wheat-tigernut residue composite flour. Colour is a very significant parameter in judging well prepared biscuits. This attribute reflects the suitable raw material used for the preparation and also provides information about the formulation and quality of the product (Feyera, 2020).

Texture is a quality attribute which is used to depict how soft or hard a cookie is and its ability to be munched easily (Porcel *et al.,* 2016). The results in Table 2 revealed that some significant differences ($p<0.05$) existed in the texture of the cookie samples with mean scores ranging from 6.50 in sample SWW (70:30 wheat-tigernut residue cookies) to 8.60 in sample SWT (100:0 wheat-tigernut residue cookies). The panelists noted that all the composite cookies samples had mild texture. The milk, egg and water used in the formulation must have contributed to this mild texture. The textural result obtained in this study is not in agreement with the findings of Senya *et al.* (2021) who reported that the panelist liked the hard texture of titbits produced from wheat-tigernut residue composite flour. The varied results could be due to differences in product formulation.

Means scores of taste of the cookie samples range between 6.50 and 8.70 and they significantly differed ($p < 0.05$) from one another except for samples SWW (70:30 wheat-tigernut residue cookies) and SWX (60:40 wheat-tigernut residue cookies) which did not differ significantly ($p > 0.05$). Sample SWT (100:0 wheat-tigernut residue cookies) had the highest taste score while the samples SWX (60:40 wheat-tigernut residue cookies) had the least score. The results showed that incorporation of tigernut residue did not adversely affect the taste of the samples. Eke-Ejiofor and Deedam (2015) reported that the taste of biscuits fortified with tigernut residue were accepted. These observations are in line with the one obtained in the present study. Apart from the presence of added sugar in the biscuits, the incorporation of tigernut residue in the product may have also contributed to their sweet taste since tigernut have been reported to contain some natural sugars (Oke *et al.,* 2019).

According to Okache *et al.* (2020), flavour is a fundamental sensory attribute which refers to the sensations in the nostrils as a result of rising of food or drink volatile compounds. The flavour scores of the cookie samples ranged from 6.60 in sample SWW (70:30 wheat-tigernut residue cookies) to 8.60 in sample SWT (100:0 wheat-tigernut residue cookies). The results showed that addition of tigernut residue flour in cookies did not affect the flavour of the samples adversely as the panelists rated all of them quite above the average. There were some significant differences ($p < 0.05$) in the flavour of the cookies. Obinna-Echem and Robinson (2019) reported close range of values (5.95 – 7.10) for the flavour of biscuits produced from maize-tigernut composite flours.

The scores adjudged for overall acceptability were within the range of 6.60 and 9.00. Sample SWT (100:0 wheat-tigernut residue cookies) had the highest score while sample SWY (50:50 wheat-tigernut residue cookies) had the least score. According to Nwatum *et al.* (2020), the baking conditions (temperature and time variables); the state of the biscuit constituents, such as fibre, starch, protein (gluten) whether damaged or undamaged and the amounts of absorbed water during dough mixing, all contribute to the final outcome of the overall acceptability. The overall acceptability scores of the cookies showed that all the samples were greatly appreciated by the panelists. However, the most accepted and highly rated samples which were samples SWT (100:0 wheat-tigernut residue cookies), SWU (90:10 wheat-tigernut residue cookies) and SWV (80:20 wheat-tigernut residue cookies) with respective overall acceptability scores of 9.00, 8.40 and 7.90 were selected for proximate analysis in order to determine the effects of the residue on the nutritional composition of the formulated cookies.

Proximate Composition of Wheat-Tigernut Residue Cookies

The results of the proximate composition of the cookies produced from composite flours of wheat and tigernut residue are presented in Table 3. The moisture content of the cookies samples ranged from 3.13 % to 3.58 %. The control sample (SWT) had the highest moisture content while the sample produced from 90 % wheat flour and 10 % tigernut residue flour (SWU) had the lowest value. There was no significant difference ($p > 0.05$) in the moisture content of the samples. It was observed that the inclusion of tigernut residue flour in the formulation slightly reduced the moisture content of the cookies. This is contrary with the report of Akujiobi (2018) who noted a significant increase in the moisture content of cookies as the level of substitution of cocoyam flour with tigernut flour increased although the percentage moisture obtained in their study (5.95 – 6.5%) is higher compared to that of the present study. Also, Obinna-Echem and Robinson (2019) reported slightly higher moisture content ranging from 3.70 – 4.60% for biscuits produced from blends of maize and tigernut flours. The variation in moisture content can be attributed to differences in the product formulation as well as environmental and experimental factors (Obasi *et al.*, 2012). The low moisture content obtained in this study is desirable for the prevention of microbial activities and extension of the shelf-life of the biscuits if protected from absorbing moisture through proper packaging.

The protein content of the samples ranged from 14.56 % to 15.61 %. There was no significant difference ($p > 0.05$) in the protein contents of the cookies. The sample made from whole wheat flour (SWT) had the highest value while sample made from 80 % wheat flour and 20 % tigernut residue flour had the least value. The results showed a very slight decrease in the protein content with inclusion of tigernut residue flour. This observation was line with the report of Eke-Ejiofor and Deedam (2015) who noted a similar decrease in the protein content of wheat biscuits fortified with dry tigernut residue. The protein content obtained in the present study are higher than values ranging from 3.94 – 11.72 % and 7.87 – 8.83 % reported by Obinna-Echem and Robinson (2019) and Akujiobi (2018) for maize-tigernut and cocoyam-tigernut composite biscuits respectively. The higher protein content obtained in this study may have also come from other raw materials such as eggs and milk used in the product formulation. Protein has been confirmed to contain some essential amino acids of great importance to the body (Ayo and Andrew, 2016).

The analysis of variance showed that there was no significant difference ($p>0.05$) in the fat content of the formulated cookies. The percentage fat content of the cookies ranged from 6.17 % in sample SWU (90:10 wheat-tigernut residue cookies) to 7.37 % in samples SWV (80:20 wheat-tigernut residue cookies). These values are lower when compared with the range of values (13.63 – 22.50%) reported by Akujiobi (2018) for cocoyam-tigernut cookies but was within the range of 5.43 – 9.57% reported by Adelekan *et al.* (2019) for plantain-tigernut chin-chin. The varied results could be attributed to the differences in the raw materials used. According to Obinna-Echem and Robinson (2019), the fat content of bakery products especially cookies could also be as a result of the function of the butter used in the formulation. High-fat content in food especially baked products can create the challenge of rancidity during storage, although fat facilitates absorption of fat-soluble vitamins, provides essential fatty acids and important volatile compounds for flavor and sensory qualities (Musa and Lawal, 2013).

The fibre content of the cookie samples ranged from 0.00 % to 0.63 % with sample SWT (100:00 wheat-tigernut residue cookies) having the lowest value while sample SWV (80:20 wheat-tigernut residue cookies) had the highest value. Statistically, there was significant difference ($p < 0.05$) in the fibre content of the samples. As was expected, the fibre content of the cookies increased significantly with increasing addition of tigernut residue flour. The range of fibre content obtained in this study is in close range with 0.83 – 0.97 % reported by Akujiobi (2018) for cocoyam-tigernut cookies but lower than 1.06 – 3.13% reported by Eke-Ejiofor and Deedam (2015) for wheat-tigernut cookies. Crude fibre composition is a measure of the quality of indigestible cellulose, pentose, lignin and other components of this type present in food (Akajiaku *et al.*, 2018). Crude fibre has little food value but it plays a role in the increased utilization of nitrogen and absorption of some other micronutrients and provides bulk necessary for peristaltic action in the intestinal tract (Obinna-Echem and Robinson, 2019).

The ash content of the cookies ranged from 0.57 % to 1.50 % with sample SWV (80:20 wheat-tigernut residue cookies) having the least value while sample SWU (90:10 wheat-tigernut residue cookies) had the highest value. There was significant difference ($p<0.05$) in the ash content of the samples. In a related study by Eke-Ejiofor and Deedam (2015), similar ash content ranging from 1.34 – 1.84% was reported for wheat-tigernut residue composite biscuits. High ash content has been related to high mineral content (Kiin-Kabari *et al.,* 2021), hence could improve the mineral level of the product and invariably that of the consumer.

Sample SWU (90:10 wheat-tigernut residue cookies) had the highest carbohydrate content of 74.29 % while sample SWT (100:0 wheat-tigernut residue cookies) had the least value of 73.27 %. There was no significant difference ($p > 0.05$) in the carbohydrate content of the samples. Carbohydrate content contributes energy value of food formulations (Okache *et al.,* 2020). The high carbohydrate in these cookies makes them ideal for all age groups most especially infants since they require energy for their rapid growth.

CONCLUSION AND RECOMMENDATION

The study has shown that healthy nutritious cookies can be produced from the composite flour of wheat and tigernut residue flours. The results showed that inclusion of tigernut residue flour did not adversely affect the sensory attributes of the cookies as the panelists liked all the formulated samples. This research study indicates that cookies produced from this composite blend contain appreciable amount of protein, fat and carbohydrate, hence can serve as relief for malnutrition. The generally low moisture content of the cookies samples is an indication that they will be shelf stable if packaged appropriately. Tigernut residue is therefore a viable substitute for wheat flour since a huge percentage of our foreign reserve is utilized in the importation of wheat. Additionally, this byproduct, which is considered as waste, can be turned to wealth and diversification in terms of usage. Thus, judicious incorporation of tigernut residue in suitable proportions into bakery products to enhance dietary quality should therefore be encouraged. This could serve as a means of tackling and combating protein-energy malnutrition and improve the health status of the vulnerable groups.

Further studies are recommended on the mineral composition, microbial qualities, market potential analysis and storage stability of the formulated cookies.

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