Onwuzuruike U.A1##, Ukegbu2, P., Obasi1, N. E., Ogah3, M., Okereke2, I., Uche2, P. C. and Echendu2, C.

1Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
2Department of Human Nutrition and Dietetics, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Nigeria.
3Department of Home Science, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Nigeria.
#Corresponding author’s Email: onwuzuruike.uzochukwu@mouau.edu.ng

Abstract—This study investigated the effect of replacing fat with avocado paste on the physical properties, dietary fibre profile and peroxide value of wheat-tigernut biscuits. 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 (100% 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%). The biscuit samples were analysed for physical properties, dietary fibre profile and peroxide value using standard procedures. Data were subjected to Analysis of variance, and means were separated using Duncan’s Multiple Range Test at p<0.05. Biscuits baked with avocado paste had higher spread ratio (6.98 – 7.19) and weight (17.39 – 17.51 g) than samples baked with margarine. Break strength of control sample was higher (185g) compared to biscuit samples baked with margarine (182.70 – 175.81 g), but lower than biscuits baked with avocado paste (182.70 – 175.81 g). Biscuits baked with avocado had higher dietary fibre profile of 7.49 to 7.84% and 5.72 to 5.82% for insoluble and soluble fibres. Biscuits containing avocado paste had higher peroxide values (1.91 to 2.56 meq O2/kg) than samples containing margarine (1.67 to 2.18 meq O2/kg). Replacing avocado with margarine improved the physical properties and dietary fibre profile of the biscuits with no adverse effect on the peroxide value and could therefore, be exploited as a healthier shortening agent to enrich biscuits.

Keywords—Biscuits, tigernut, avocado pear, wheat, dietary fibre

I. INTRODUCTION

Biscuits are ready-to-eat baked products made from single or composite flour, sugar, milk, eggs, fat, flavouring agents and other raising agents [1], and usually consumed worldwide as a snack food [2]. Biscuits contain considerable amount of fat and are usually dried to low moisture content [3].

Fat is an important ingredient in baked products and contributes to providing desirable textural and structural properties to biscuits [4]. Fat in baked products lubricate, weaken, or shorten the structure of food components to provide desirable food products with desirable textural properties [4]. Fat is the main ingredient that is responsible for the tenderness of biscuits and its combination with other ingredients in baked products help to develop mould texture, mouthfeel and overall sensation of lubrication of the product [5]. Fat also keeps the quality, grain and texture and adds to the richness of the biscuit [6]. The overall quality of biscuit is determined by the type of fat used in baking. Consumption of saturated fats from baked products is highly prevalent and is a cause for nutritional concern [7]. Studies have reported that consumption of fat in large amounts
AVOCADO PASTE REPLACING FAT IN BISCUIT MAKING

A. Source of raw materials

Wheat flour (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 in the month of March. All reagents used in this study were of analytical grade.

B. Methods

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 as described by [19] and [27]. 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.

Dietary fibre is a component of food that cannot be broken down by enzymes in the human digestive tract to produce small absorbable components in the blood stream but pass through the stomach and small intestine virtually unchanged [22]. They are found basically in plant materials, including fruits, vegetables, cereals, legumes, tubers, roots and nuts. Dietary fibres are either soluble or insoluble, both of which may or may not be present in the same plant material and work better when in combination than in isolation. Soluble fibres are those fibres that dissolve or swell in water and are metabolized by bacteria in the large intestine [23]. Soluble fibres include pectin, gum and mucilage, and are associated with lowering of the risks of chronic diseases [24]. They also add pleasant consistency in food. Insoluble fibres are fibres that do not dissolve in water and are not metabolized by bacteria in the large intestine. They include cellulose, hemicelluloses and lignin [25]. They make stool heavier and speed their passage through the gut. They are sponge – like mass, absorbing many times their weight of water, swelling up and helping to eliminate faeces and relieve constipation [26].

II. Material and Methods

A. Source of raw materials

Wheat flour (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 in the month of March. All reagents used in this study were of analytical grade.

B. Methods

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 as described by [19] and [27]. 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.

for a long period is associated with health problems such as cardiovascular diseases [8], thus making it imperative to search for healthier alternatives from local crops. To reduce the intake of saturated fats from baked products, replacement of fat with healthier plant options like avocado is advocated [9].

Avocado paste was used as an ingredient to replace fat in this study. The choice of avocado stems from consumer demand for health-promoting foods with nutritional relevance, coupled with the drift away from trans-fat consumption from baking margarine to healthier plant fat consumption from fruits. Avocado has a butter-like texture, thus suggesting its use as a fat replacer in biscuit making [9]. It is also recognized as a functional food that contains health-promoting phytochemicals and dietary fibre [9]. The pulp of mature avocado fruit is rich in proteins, fats and oils and low in sugar [10]. Avocado due to its low cost, pleasing taste and predominance of monounsaturated fatty acids [11] can be used to partially or wholly replace margarine in biscuit making [9, 12]. [12] showed that substituting margarine with avocado pear pulp up to 50% in conventional wheat cookies improved appearance, physical, nutritional quality as well as general acceptability of the product. [11] reported similar physical and overall acceptability when avocado paste was used to replace margarine with improved nutritional content in the variations for cookies made using avocado as butter substitute. Another study conducted by [9] on physico-chemical and sensory properties of cookies produced by partial substitution of margarine with avocado pear (Persia americana) showed that partial substitution of margarine with avocado pear pulp produced nutritious cookies with desirable organoleptic qualities. Also, the results demonstrated that cookies had acceptability up to a 30% level of substitution with avocado pear pulp.

Wheat is a critical raw material in biscuit making and is superior to other cereals due to its high gluten content [13]. Wheat also has the ability to form a cohesive gluten network when worked with water, and the presence of gluten imparts certain qualities to the finished product [14]. The need to develop composite flours using local crops like tigernut tubers in the production of biscuits, breads and confectioneries have been advocated in the bakery industry. This is to improve nutritional and health benefits, reduce cost of wheat importation, reduce allergy to gluten-sensitive individuals and provide functional contribution to health [15].

Tigernut (Cyperus esculentus L.) is known as Aya in Hausa, Ofio in Yoruba, Aki in Igbo and Shoho in Tiv language [16]. Tigernut has a sweet and nutty taste [17] and the tubers are edible and can be eaten raw, dried, roasted, and prepared as tiger nut milk or oil, as well as used as a composite in the production of confectioneries [18]. The use of tigernut flour in biscuit making is desirable due to its constituent of dietary fiber [19], carbohydrate, [20], oil content and antioxidant capacity [19]. The use of wheat-tigernut flour blends in biscuit making has been reported [9, 12, 21].

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 as described by [19] and [27]. 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 ratio 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 replaced with mature and ripe avocado paste (100%).

Preparation of biscuits

A modified recipe of [28] was adopted using the rubbing-in method. All the ingredients contained in the recipe are presented in 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 procedure was followed in the production of biscuits as is the case with the first batch, however, the baking margarine was replaced with avocado paste as an ingredient in the samples. Biscuit made from 100% wheat flour served as the control.

Determination of Dietary fibre

The total dietary fibre, soluble dietary fibre and insoluble dietary fibre was determined by the method described by [29].

Total dietary fibre: Enzymatic-Gravimetric Method was used to measure total dietary fibre using phosphate buffer systems as described by [29]. Duplicate portions of the sample were gelatinized and partially digested with alpha-amylase and then enzymatically digested with protease and amyloglucosidase to remove the protein and starch present in the sample, simulating human digestion. Ethanol was added to precipitate the soluble dietary fibre. The residue was filtered and washed with ethanol and acetone, then dried, and weighed. One portion of the sample was analysed for protein and the other was ashed. Total dietary fibre was calculated as the weight of the residue minus the weight of the protein and ash, reported as a percentage of the original sample weight.

\[
\text{TDF} = \frac{\text{Wr} - (\text{Wp} + \text{Wa}) \times 100}{\text{Sw}}
\]

Where:
- \(\text{Wr}\) = weight of residue
- \(\text{Wp}\) = weight of protein
- \(\text{Wa}\) = weight of ash

Sw = sample weight

Soluble (SDF) and insoluble (IDF) dietary fibre: This was measured using an MES-Tris buffer as described by [29]. The sample was defatted and dispersed in buffer, the starch gelatinized and partially digested with alpha-amylase, and then further digested with protease and amyloglucosidase enzymes. The undigested IDF mass was removed by filtration, dried, and weighed. Ethanol was added to the filtrate to precipitate the soluble dietary fibre. The undigested SDF mass was isolated, dried, and weighed.

Determination of Physical properties

The physical characteristics including weight, height, spread ratio, diameter and break strength of the biscuit samples were determined according to the method described by [30]. Weight was measured as average values of four individual biscuits with the help of an analytical weighing balance (Model number:12043, Nez Delhi). Average values for weight was reported in grams (g). Height was measured as an average values of four individual biscuit using a manual Vernier calliper. Average values was reported in centimetre (cm). Spread ratio was calculated by dividing diameter by thickness. Thickness of biscuits was determined by measuring the diameter of four biscuit samples placed edge to edge with a digital Vernier calliper. An average of four values was taken for each set of samples. Average value for thickness was reported in millimetre (mm). Diameter of the biscuits was determined by placing four biscuit samples edge to edge and measuring with a digital Vernier calliper. An average of four values was taken for each set of samples. Average value for diameter was reported.

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

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.
in millilitre (ml). Break strength was evaluated by placing biscuits of known height between two bars. Known weight that caused the breaking of the biscuit was regarded as the break strength of the biscuits.

**Determination of peroxide value**

The peroxide value was determined by the method described by [31]. Biscuit samples were first ground into powder and mixed with distilled water (1:1 weight/vol) to obtain a homogenous solution. Two milliliters (2 ml) of biscuit solution was added in a test tube. Two milliliters (2 ml) of potassium iodide and 20 ml of acetic acid and di-chloromethane (CH₃COOH: CHCl₃ i.e. 2:1) was added to it. The content in the tube was allowed to boiled for 30 seconds by placing the test tube in a boiling water bath. This was followed by boiling at 100°C for another 30 seconds. The test tube was cooled down immediately using tap water to 20°C before transferring it into a 500 ml conical flask. Twenty milliliters (20 ml) of potassium iodide and 50 ml of distilled water were added to the conical flask and titrated against 0.002 N sodium thiosulphate until the yellow colour almost disappeared. At this time, 2 drops of starch solution which is serving as an indicator was added and titration continues until the blue-black coloration turns colorless. Peroxide value of biscuit samples was calculated in duplicates as follows:

\[
\text{Peroxide value (meq O}_2/\text{kg) =} \frac{V}{W} \times (\text{ml of 0.002 N sodium thiosulphate per ml})
\]

Where, \( V = \text{ml of 0.002N. Na}_2\text{S}_2\text{O}_3 \) used.

\( W = \text{weight of the sample taken in milliliters.} \)

**Statistical Analysis**

Data obtained were subjected to descriptive statistics and means subjected to one-way analysis of variance (ANOVA). Means where significantly different at \( p < 0.05 \) were separated using Duncan’s Multiple Range Test (DMRT) with Statistical Package for the Social Science Version 15.0.

**III. RESULT AND DISCUSSION**

**Physical appearance of biscuit samples**

**Figure 1-7** shows the physical appearance of seven biscuit samples with different levels of whole tigernut flour and avocado substitution. Appearance became darker as the whole tigernut flour substitution increased. Texture increased in roughness, and became grainy with increasing substitution of whole tigernut flour. Notably, composite samples containing avocado paste (AT10 to AT30) as the shortening agent appeared lighter compared to composite samples containing margarine (T10 to T30).

**Physical properties of biscuit samples**

Physical properties of biscuit samples are shown in **Table 2**. The properties differ significantly (\( p<0.05 \)) among the samples except diameter and height. Height ranged from 0.95 to 1.23 cm and was similar in all the biscuit samples. Control sample (T00) had higher height (1.23 cm) than composite samples (p>0.05). The values obtained in this study for height was similar to height of 9.01 to 16.02 mm (0.91cm to 1.6cm) reported by [11] for cookies produced using avocado as a fat (butter) substitute.

Diameter ranged from 20.12 to 21.03 mm, and was also similar in all the biscuit samples. Our results are in line with values
Our milk permeate and soft wheat flour – 75 to 7.50 reported by [11] for cookies made using avocado as a fat (Butter) substitute. Similarly, [33] reported higher diameter of 53.00 to 55.60 mm for biscuits produced from a mixture of tiger nut flour, milk permeate and soft wheat flour compared to results of this study. The variations in diameter of the biscuit samples may be attributed to differences in raw material, recipe as well as the methods used in processing the composites and producing biscuits.

The weight of the biscuit samples ranged from 15.94 to 17.51 g. These values increased as the proportion of whole tigernut flour increased to 30%. The values for weight obtained in this study corresponds with 13.73 to 19.03 g reported by [21] for biscuits produced from wheat-tigernut composite flour, but lower than 16.25 to 20.37 g reported by [11] for cookies made using avocado as a fat (Butter) substitute. [33] and [32] reported lower weight of 8.40 to 9.12 g and 6.42 to 8.33 g for biscuits produced from mixture of tiger nut flour, milk permeate and soft wheat flour and biscuits produced from yellow yam, unripe plantain and pumpkin seed flour blends, respectively. The weight of biscuits baked with avocado was significantly higher than weight for biscuits baked with margarine as well as the control sample (P<0.05). Higher weight of biscuits baked with avocado paste over those baked with margarine may be due to higher water holding capacity in non- and reduced wheat protein than in wheat flour [34]. Again, increased moisture of biscuits baked with avocado paste may have contributed to their higher weight.

The composite samples had significantly higher spread ratio compared to the control sample (T00). Spread ratio of composite biscuits increased as the proportion of whole tigernut flour increased to 30%. Comparatively, using avocado paste as a shortening agent resulted in biscuits with higher spread ratio (6.98 – 7.19) than samples baked with margarine (6.80 – 7.11). The values obtained in this study was higher than 1.95 to 7.70 reported by [11] for cookies made using avocado as a fat (Butter) substitute, 4.75 to 7.50 reported by [21] for biscuit produced from wheat-tigernut composite flour and 5.20 to 5.93 reported by [35] for Acha-tigernut composite biscuits. [36] reported similar spread ratio of 5.42 to 6.55 for functional cookies developed from plantain peel flour as a potential source of antioxidant dietary fibre, while [33] reported higher value of 9.40 to 11.00 for biscuits produced from mixture of tiger nut flour, milk permeate and soft wheat flour. Spread ratio is an indicator of binding properties and texture. Higher spread ratios are desirable in biscuits. Reduction in spread ratio has been attributed to hydrophilic nature of flours used in the production of biscuits [30, 37]. Increased spread ratio as whole tigernut substitution increased could be due to high fibre content of tigernut, which could decrease the viscosity of the dough prior to baking. [39] reported that spread ratio increases with increase fibre content in biscuits. Dough with lower viscosity cause biscuits to spread at faster rate [39]. Higher spread ratio obtained for biscuits baked with avocado paste can be attributed to higher water content of avocado fruit. When more water is present in dough, more sugar is dissolved during mixing. This lowers the initial dough viscosity and the biscuit is able to spread at a faster rate during heating [39].

The reduced break strength of biscuits substituted with whole tigernut flour and baked with margarine compared to the control samples could be caused by the increase in the fibre content resulting in weakening of the bond between the carbohydrate-carbohydrate and carbohydrate-protein molecules [40]. However, biscuits baked with avocado paste had higher break strength which may be attributed to the increased moisture that may have affected the factorability of the biscuits [36] reported lower break strength of 53.67 to 68.11 g for functional cookies developed from plantain peel flour as a potential source of

### TABLE 2

<table>
<thead>
<tr>
<th>Samples</th>
<th>Spread ratio</th>
<th>Weight (g)</th>
<th>Diameter (mm)</th>
<th>Height (cm)</th>
<th>Break strength (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T00</td>
<td>6.23±0.34</td>
<td>17.10±0.04</td>
<td>20.76±0.06</td>
<td>1.23±0.02</td>
<td>185.15±0.78</td>
</tr>
<tr>
<td>T10</td>
<td>6.80±0.01</td>
<td>15.94±0.02</td>
<td>21.03±0.01</td>
<td>1.00±0.01</td>
<td>182.70±0.14</td>
</tr>
<tr>
<td>T20</td>
<td>6.95±0.01</td>
<td>16.31±0.01</td>
<td>20.59±0.01</td>
<td>1.00±0.01</td>
<td>179.50±0.14</td>
</tr>
<tr>
<td>T30</td>
<td>7.11±0.01</td>
<td>16.59±0.01</td>
<td>20.69±0.01</td>
<td>0.99±0.02</td>
<td>175.81±0.01</td>
</tr>
<tr>
<td>AT10</td>
<td>6.98±0.04</td>
<td>17.39±0.02</td>
<td>20.12±0.03</td>
<td>0.97±0.05</td>
<td>195.70±0.14</td>
</tr>
<tr>
<td>AT20</td>
<td>7.10±0.01</td>
<td>17.46±0.02</td>
<td>20.03±0.02</td>
<td>1.00±0.02</td>
<td>196.60±0.14</td>
</tr>
<tr>
<td>AT30</td>
<td>7.19±0.01</td>
<td>17.51±0.01</td>
<td>20.84±0.47</td>
<td>0.95±0.02</td>
<td>189.40±0.07</td>
</tr>
</tbody>
</table>

- Values are means ± SD of duplicate determination. Mean value in the same column but with different superscript are significantly different (P<0.05).

The break strength of control sample is 185.15 g, break strength of biscuits baked with margarine ranged from 182.70 – 175.81 g, while samples baked with avocado paste have a break strength range of 195.70 – 189.40 g. This indicates that the break strength of control sample was higher than biscuit samples baked with margarine, but lower than biscuits baked with avocado paste. Biscuits substituted with avocado paste had higher break strength. Again, break strength decreased progressively for samples baked with either margarine or fat substitute, as the level of whole tigernut substitution increased.
antioxidant dietary fibre than the values obtained in this study, while [40] reported higher break strength of 320 to 570 g for Acha-tigernut composite biscuits.

**Dietary fibre profiles of biscuit samples**

Figure 2 presents dietary fibre profile of biscuit samples baked with different levels of whole tigernut flours as well as avocado paste as fat substitute. Dietary fibre of control sample was significantly (p<0.05) lower than the composite samples. In each of the biscuit samples, insoluble fibre content was higher than the soluble fibre content, and each of these components of dietary fibre increased significantly (p<0.05) with increasing addition of whole tigernut flour. Insoluble and soluble fibre content increased respectively from 1.95% to 7.72% and 0.57% to 5.75% for biscuits baked with margarine when the level of whole tigernut flour substitution increased from 0 to 30%. In comparison to biscuits baked with avocado, higher values which ranged from 7.49% to 7.84% and 5.72% to 5.82% were obtained for insoluble and soluble fibres, respectively. Avocado fruit has been reported to contain about 3% dietary fibre [41], which might be responsible for the increase in the avocado substituted biscuit samples. The values obtained in this study were lower than 13.26 to 36.74%, 8.43 to 26.87% and 4.83 to 9.87% reported by [36] for total, insoluble and soluble dietary fibres, respectively of functional cookies developed from plantain peel flour as a potential source of antioxidant dietary fibre.

Insoluble dietary fibers are unable to digest and are poorly metabolized in the small intestine [42]. They have passive holding characteristics that can reduce the risk of constipation, diverticular disease and haemorrhoids [43]. Soluble dietary fibre develops gel forming characteristics during digestion which slows down the food as digestion takes place and this contributes to many health benefits such as postprandial blood glucose, serum cholesterol and insulin levels [44]. Thus, substitution of wheat flour with whole tigernut flour and inclusion of avocado paste improved the dietary fibre profile of biscuit samples for healthier nutrition, as showed in figure 8 below.

**Peroxide value of biscuit samples**

The result of peroxide value (PV) are presented in Table 3. Significant differences were observed among the samples (p<0.05). Control sample (T00) had the lowest value (1.42 meq O₂/kg). Biscuits containing fat substitute had higher peroxide values (1.91 meq O₂/kg for AT10 to 2.56 meq O₂/kg for AT30) than samples containing margarine (1.67 meq O₂/kg for T10 to 2.18 meq O₂/kg for T30). This outcome may be due to the crude nature of the avocado paste which may possibly contain components such as chlorophyll1 that promotes the deterioration of fat and development of hydrogen peroxides, a primary oxidation product. In both cases, the peroxide values increased as the level of whole tigernut flour substitution increase. Food products with peroxide value below 10 meq O₂/kg are classified as fresh and safe for consumption [45]. Therefore, the biscuit samples with a PV below 10 meq O₂/kg are low oxidation state samples, fresh and fit for consumption. PV is an important indicator of oxidative rancidity, as it reflects the degree of lipid oxidation by indicating the level of primary oxidation products [46]. Peroxides are the main primary oxidation products. High amounts of peroxides amount to low oxidative stability [47]. PV decreases as secondary oxidation products appear as such, low PV could suggest the occurrence of advanced oxidation [48]. Therefore, a low PV does not indicate that the biscuits are good, it only gives an indication of the current state of oxidation of the biscuits [49]. The peroxide value obtained in this study was lower than 2.96 to 5.27 meq O₂/kg reported by [9] for cookies produced by partial substitution of margarine with avocado pear (Persia americana).

### Table 3

<table>
<thead>
<tr>
<th>Samples</th>
<th>Peroxide value (meq O₂/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T00</td>
<td>1.42±0.01</td>
</tr>
<tr>
<td>T10</td>
<td>1.67±0.02</td>
</tr>
<tr>
<td>T20</td>
<td>1.87±0.04</td>
</tr>
<tr>
<td>T30</td>
<td>2.18±0.03</td>
</tr>
<tr>
<td>AT10</td>
<td>1.91±0.01</td>
</tr>
<tr>
<td>AT20</td>
<td>2.41±0.06</td>
</tr>
<tr>
<td>AT30</td>
<td>2.56±0.39</td>
</tr>
</tbody>
</table>

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.

### IV. Conclusion

This study evaluated the effect of substituting wheat flour with whole tigernut flour up to 30% and replacement of margarine with avocado paste as the shortening agent for biscuit production. Spread ratio and weight increased with increased substitution of whole tigernut flour for biscuit samples where...
either margarine or avocado paste was used as the shortening agent. Biscuits containing avocado paste as the shortening agent had better dietary fibre profile than other samples. Peroxide value was lower in the control sample, however, the value obtained showed that all samples are still fresh and fit for consumption. Therefore, healthier bakery products can be developed by utilizing whole tigernut flour and avocado fruit as a valued dietary source to enrich bakery products like biscuits in the country.

ACKNOWLEDGMENT

This research was funded by TETFUND and Michael Oppkara University of Agriculture, Umudike Institutional Based Research grant.

REFERENCES

Production of biscuits from mixture of tiger nut flour, milk permeate and soft wheat flour. Asian Food Science Journal 2020, 18(2): 11-21


