Indonesian Food Science and Technology Journal
IFSTJ : Vol 7 No 1; December 2023 ; (PP : 67-74)
ISSN : 2615-367X

INDONESIAN FOOD SCIENCE AND TECHNOLOGY JOURNAL (IFSTJ)

Journal homepage : online-journal.unja.ac.id/ifstj/issue/archive

Physical Properties, Dietary Fibre Profile and Peroxide Value of Biscuits Produced from Wheat-Tigernut Flours with Avocado Paste as A Fat Substitute

Onwuzuruike U.A[1#]., Ukegbu[2], P., Obasi[1], N. E., Ogah[3], M., Okereke[2], I., Uche[2], P. C. and Echendu[2], C.

[# 1]Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]Department of Human Nutrition and Dietetics, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Nigeria.
[3]Department 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 O_2/kg) than samples containing margarine (1.67 to 2.18 meq O_2/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

Manuscript received June 23, 2023; revised September 31, 2023; accepted Dec 28, 2023. Available online Dec 30. 2023

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 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].

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 feaces 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.

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 amyl glucosidase 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.

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

Where:

Wr = weight of residue
Wp = weight of protein
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.

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.

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 caliper. 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 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 obtained 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 (CH_3COOH: $CHCl_3$ 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:

Peroxide value **(**meq O_2/kg**)** =

$$\frac{V}{W}\ (\text{ml of } 0.002\ \text{N. Sodium thiosulphate per ml})$$

Where, V = ml of 0.002N. $Na_2S_2O_3$ used.
W= 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).

Fig. 1: T00 (0% whole tigernut flour)

Fig. 2: T10 (10% whole tigernut flour)

Fig. 3: T20 (20% whole tigernut flour)

Fig. 4: T30 (30% whole tigernut flour)

Fig. 5: AT10 (10% whole tigernut flour with avocado paste)

Fig. 6: AT20 (20% whole tigernut flour with avocado paste)

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

Fig 1-7: Physical appearance of seven biscuit samples with different levels of whole tigernut flour and avocado substitution.

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

(37.27 to 39.33 mm) reported by [32] for biscuits produced from wheat flour, yellow yam flour and blends of yellow yam, plantain and pumpkin seed flours, but higher than 5.67 to 8.50 mm for biscuits produced from wheat-tiger nut composite flour. Again, the values obtained in this study are lower than 41.86 to 65.76 mm 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-tiger nut 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].

TABLE 2
PHYSICAL PROPERTIES OF WHEAT-TIGERNUT COMPOSITE BISCUIT SAMPLES.

Samples	Spread ratio	Weight (g)	Diameter (mm)	Height (cm)	Break strength (g)
T00	$6.23^{c}\pm0.34$	$17.10^{d}\pm0.04$	$20.76^{a}\pm0.06$	$1.23^{a}\pm0.02$	$185.15^{d}\pm0.78$
T10	$6.80^{b}\pm0.01$	$15.94^{g}\pm0.02$	$21.03^{a}\pm0.81$	$1.00^{a}\pm0.01$	$182.70^{e}\pm0.14$
T20	$6.95^{b}\pm0.01$	$16.31^{f}\pm0.01$	$20.59^{a}\pm0.01$	$1.00^{a}\pm0.01$	$179.50^{f}\pm0.14$
T30	$7.11^{a}\pm0.01$	$16.59^{e}\pm0.01$	$20.69^{bc}\pm0.01$	$0.99^{a}\pm0.02$	$175.81^{g}\pm0.01$
AT10	$6.98^{b}\pm0.04$	$17.39^{c}\pm0.02$	$20.12^{a}\pm0.31$	$0.97^{a}\pm0.01$	$195.70^{a}\pm0.14$
AT20	$7.10^{b}\pm0.01$	$17.46^{b}\pm0.02$	$20.05^{a}\pm0.42$	$1.00^{a}\pm0.02$	$194.60^{b}\pm0.14$
AT30	$7.19^{a}\pm0.01$	$17.51^{a}\pm0.01$	$20.84^{a}\pm0.47$	$0.95^{a}\pm0.02$	$189.40^{c}\pm0.07$

a-g: Values are means ± SD 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.

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.

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 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

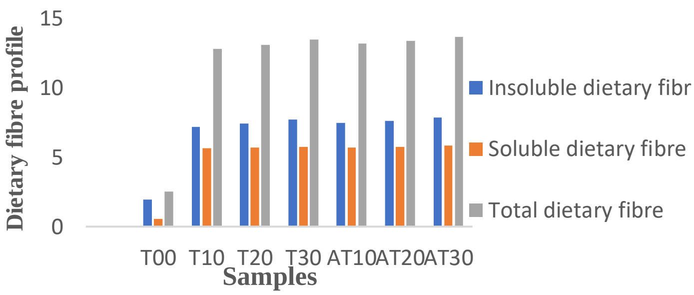

Fig. 8: Dietary fibre composition of biscuits samples influenced by whole tigernut flour inclusion and avocado paste. T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30= 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

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 O_2/kg). Biscuits containing fat substitute had higher peroxide values (1.91 meq O_2/kg for AT10 to 2.56 meq O_2/kg for AT30) than samples containing margarine (1.67 meq O_2/kg for T10 to 2.18 meq O_2/kg for T30). This outcome may be due to the crude nature of the avocado paste which may possibly contain components such as chlorophy11 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 O_2/kg are classified as fresh and safe for consumption [45]. Therefore, the biscuit samples with a PV below 10 meq O_2/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

PEROXIDE VALUE OF COMPOSITE BISCUIT SAMPLES

Samples	Peroxide value (meq O_2/kg)
T00	$1.42^{f}\pm0.01$
T10	$1.67^{e}\pm0.02$
T20	$1.87^{d}\pm0.04$
T30	$2.18^{c}\pm0.03$
AT10	$1.91^{d}\pm0.01$
AT20	$2.41^{b}\pm0.06$
AT30	$2.56^{a}\pm0.39$

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

[1] JA, Ayo, and FE, Gidado. Physicochemical, phytochemical and sensory evaluation of acha-carrot flours blend biscuit. Current Journal of Applied Science and Technology 2017, 25(5):1-15.

[2] BL, Nermin. Improvement of nutritional properties of cake with wheat germ and resistance starch. Journal of Food and Nutritional Research, 2013, 52(4):210-218.

[3] S. Kumar, and LK, Rekha-Sinha. Evaluation of quality characteristics of soy based millet biscuits, Advances in Applied Science Research 2010, 1:187-196.

[4] M, Hasmadi and EH, Sandra. Effect of fat types on the structural and textural properties of dough and semi-sweet biscuit. Journal of Food Science and Technology 2014, 51(9):1998–2005.DOI 10.1007/s13197-012-0708-x

[5] CE, Stauffer. Fats and oils in bakery products. Cereal Foods World 1998, 43:120–126

[6] CM, O'Brien, D, Chapman, DP, Neville, MK, Keogh, EK, Arendt. Effect of varying the microencapsulation process on the functionality of hydrogenated vegetable fat in short dough biscuits. Food Research International 2003, 36:215–221

[7] O, Carvajal-Zarrabal, C, Nolasco-Hipolito, MG, Aguilar-Uscanga, G, Melo-Santiesban, PM, Hayward-Jones, DM, Barradas-Dermitz. Avocado oil supplementation modifies cardiovascular risk profile markers in a rat model of sucrose-induced metabolic changes. Disease Markers 2014, 9:386-425.

[8] S, Engel and T, Tholstrup. Butter Increased Total and LDL Cholesterol Compared with Olive Oil but Resulted in Higher HDL Cholesterol Compared with a Habitual Diet. The American Journal of Clinical Nutrition, 2015 102(2):309-315. https://doi.org/10.3945/ajcn.115.112227

[9] BH, Jelili, IQ, Joseph, AM, Esther, BK, Seember. Physico-chemical and Sensory Properties of Cookies Produced by Partial Substitution of Margarine with Avocado Pear (Persia americana). Croatian Journal of Food Science and Technology 2021, 13 (1): 1-9. DOI: 10.17508/CJFST.2021.13.1.12

[10] AO, Nurul, AM, Marina and H, Sakinah. The effect of avocado puree as fat replacer on the physical quality of muffin. Malaysian. Applied Biology 2016, 45(2): 11–16.

[11] M, Pooja, M, Indran and J, Simmi. Study on the physic-chemical and Sensory Characteristics of Cookies made Using Avocado as Fat (Butter) Substitute. International Journal of Food Science and Nutritio 2018, 3(1):68-72.

[12] PA, Adie, DE, Enenche, TM, Atsen, and CO, Ikese. Physicochemical and Sensory Evaluation of Cookies Produced by Partial Substitution of Margarine with Avocado (*Persia americana*) Pulp. Asian Food Science Journal 2020, 18(2): 41-47.

[13] M, Hasmadi, M, Patricia, J, Salwa, FMA, Siti, AH, Mansoor and SR, Ainnur. Effect of fat types on the structural and textural properties of dough and semi-sweet biscuit. Journal of Applied Phycology 2013, DOI 10.1007/s10811-013-0082-8

[14] P, Sharma and HS, Gujra. Cookie making behaviour of wheat–barley flour blends and effects on antioxidant properties. LWT - Food Science and Technology 2014, 55(1):301–307

[15] MJ, Ihsanullah, TNK, Qureshi and J, Akhtar. Determination of iron in different types of wheat flours. International Journal of Agriculture and Biology 2002, 4(2):297- 299.

[16] SZ, Ahmed and MS, Hussein. Exploring the suitability of incorporating tiger nut flour as novel ingredients in gluten free biscuit. Polish Journal of Food and Nutrition Sciences 2014, 64(2): 27-33

[17] JA, Adejuyitan. Tigernut processing: Its food uses and health benefits, American Journal of Food Technology 2011, 6: 197-201.

[18] OA, Abiodun, OO, Oladeinde, KL, Funmilola, FA, Femi, OA, Deborah and OA, Samuel. Production and acceptability of chinchin snack made from wheat and tigernut (Cyperus esculentus) flour, Cogent Food and Agriculture 2017, 3(1): 128-185.

[19] II, Adedokun, SU, Okorie, and B, Batu. Evaluation of proximate, fibre qualities and consumer acceptability of bambaranut- tigernut – coconut milk beverage blends, International Journal of Nutrition and Food Sciences 2014, 3 (1): 430-437.

[20] MU, Ukwuru and AC, Ogbodo. Effect of processing treatment on the quality of Tigernut milk. Pakistan Journal of Nutrition 2013, 10 (1): 95-100.

[21] G.S, Kwaghsende, GU, Ikala and PO, Ochelle. Quality evaluation of biscuit from wheat-tiger nut composite flour. International Journal of Agriculture and Plant Science 2019, 1(3):25-30

[22] OE, Adedeji, OD, Oyinloye and OB, Ocheme. Effects of germination time on the functional properties of maize flour and the degree of gelatinization of its cookies. African Journal of Food Science 2014, 8: 42-47.

[23] JH, Goben, AR, Kristal and JL, Standford. Fruits and vegetables intakes and postrate cancer risk. Journal of the National Cancer Institute 2000, 92(1): 61-68.

[24] X, Mei, TH, Mu and JJ, Han. Composition and physicochemical properties of dietary fiber extracted from residues of 10 varieties of sweet potato by a sieving method. Journal of Agriculture, Food and Chemistry 2012, 58,7305-7310.

[25] AJ, Gordon AJ. Characteristics of sugar beat fibres allow many food uses. Cereal Foods World 2009, 34:541 – 506.

[26] N, Painters. ''Diverticular disease of the colon. In: H, Trowel, D, Burkilt, and Hernson K. eds. Dietary Fibre Depleted Foods and Diseases''. Academic Press, New York, 145- 160, 2007

[27] PO, Ukegbu, NE, Obasi, UA, Onwuzuruike, M, Ogah, I, Okereke, PC, Uche and C, Echendu. Comparative analysis of the proximate and sensory properties of wheat-whole tigernut biscuits replaced with avocado paste. Nigeria Journal of Nutritional Sciences 2022, 44(1):13-24

[28] UA, Onwuzuruike, ND, Onuoha and UC, Uzowhukwu. Nutrient assessment of gluten free biscuit from African pear and orange flesh sweet potato flour blends. Journal of Agricultural, Food Science and Biotechnology 2023, 1(2). 83-94,

[29] AOAC. Official methods of Analysis (13th edn). Association of Official Analytical Chemists, Washington DC, 2012.

[30] JA, Ayo, VA, Ajo, C, Popoola, M, Omosebi and L, Joseph L. Production and evaluation of malted soybean-acha composite flour bread and biscuit. African Journal of Food Science and Technology 2007, 5(1): 21-28.

[31] AOCS. American Oil Chemists' Society Official Methods and Recommended Practices of the American Oil Chemists' Society Champaign. Method Cd 1d-92, 1993

[32] AB, Florence, JN, Ofonim and SO, Babatunde. Assessment of chemical compositions, physical and sensory properties of biscuits produced from yellow yam, unripe plantain and pumpkin seed flour blends. International Journal of Food Science and Nutrition Engineering 2018, 8(5): 119-126.DOI: 10.5923/j.food.20180805.02

[33] E, Moustafa, MSH, Ahmed, and TF, Mohamed. Production of biscuits from mixture of tiger nut flour, milk permeate and soft wheat flour. Asian Food Science Journal 2020, 18(2): 11-21

[34] P, Hoojjat and, ME, Zabik. Sugar-snap cookies prepared with wheat navy bean-sesame seed flour blends. Cereal Chemistry 1998, 61(1):41-44.

[35] JA, Ayo, MO, Ojo, CA, Popoola, VA, Ayo1 and A, Okpasu. Production and quality evaluation of acha-tigernut composite flour and biscuits. Asian Food Science Journal 2018, 1(3): 1-12.

[36] KB, Arun, P, Florence, PS, Aswathy, C, Janu, MS, Sajeev, P, Jayamurthy and P, Nisha. Plantain peel - a potential source of antioxidant dietary fibre for developing functional cookies. Journal of Food Science and Technology 2015, DOI 10.1007/s13197-015-1727-1

[37] JC, Okaka, ENT, Akobuundu and ANC, Okaka. Food and Nutrition: An Integrated Approach. Ocjanco Academic Publishers Enugu, Nigeria. Pp .154-163, 2009.

[38] P, Tangkanakul, P, Tungtrakul and N, Vatanasuchart. Physical and chemical properties of high fibre breads and cookies. http://agris.fao.org/aos/records/ TH2000000922, 209–210, 1996;

[39] RC, Hoseney and DE, Rogers. ‘’Mechanism of sugar functionality in cookies. In Faridi, H. (Ed.). The Science of Cookie and Cracker Production’’. New York. Avi, 203-226, 1994

[40] S, Dhingra and S, Jood S. Physico-chemical and nutritional properties of cereal-pulse blends for bread making. Nutrition and Health 2002, 16(3):183-94.

[41] HF, Soares and MK, Ito. The Monounsaturated Fatty Acids from Avocado in the Control of Dyslipidemia. Revistacliencias Medica 2000, 9(2), 47-51.

[42] H, Englyst, HS, Wiggins and JH, Cummings. Determination of nonstarch polysaccharides in plant foods by gas-liquid chromatography of constituent sugars as alditol acetates. Analyst 2007, 107:307–318.

[43] NE, Anderson and FM, Clydesdale. An analysis of the dietary fiber content of a standard wheat bran. Journal of Food Science 1980, 45: 336

[44] DJA, Jenkins, TMS, Wolever, AR, Leeds, MA, Gassull, P, Haisman, J, Dilawari, DV, Goff, GL, Meta and KGMM, Albert. Dietary fibres, fibre analogues and glucose tolerance: importance of viscosity. British Medical Journal 2000, 1:1392–1394

[45] D, Moigradean, M, Poiana and I, Gogoasa. Quality Characteristics and Oxidative Stability of Coconut Oil During Storage. Journal of Agroalimentary Processes and Technologies 2012 2012, 18(4), 272-276

[46] M, Fu, O, Qu, X, Yang and X, Zhang. Effect of intermittent oven drying on lipid oxidation, fatty acids composition and antioxidant activities of walnut. Lebensmittel-Wissenschaft + Technologie 2018, 65:126-1132. http://dx.doi.org/10.1016/j.lwt.2015.10.002

[47] Y, Yang, X, Song, X, Sui, B, Qi, W, Wang, Y, Li and L, Jiang. Rosemary extract can be used as a synthetic antioxidant to improve vegetable oil oxidative stability, Industrial Crop and Products 2016, 80: 141-147.

[48] MM, Chakraborty. Chemistry and technology of oils and fats. Allied Publishers Private Ltd. Pp 752. 2016

[49] NEG, Frank, ME, Albert and D, Ekwe. Assessment of the quality of crude palm oil from small holders in Cameroon. Journal of Stored Products Postharvest Reserve 2011, 2:52-58