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QUALITY EVALUATION OF SHORTBREAD BISCUITS PRODUCED FROM WATER YAM-WHEAT FLOUR BLENDS

[1]Ubbor, S. C., [2]Ekeh, J. I., [3]Ejechi, M. E., [1]Ndife, J., [1]Agwo, O.E. and [1]Iguh, B. N.
[1]Department of Food Science and Technology,
[2]Department of Agriculture/Home Economics Education,
[1,2]Michael Okpara University of Agriculture, Umudike, PMB 7267, Umuahia, Abia State, Nigeria.
[3]Farming System Research Program, National Root Crops Research Institute, Umudike,
PMB 7006, Umuahia, Abia State, Nigeria.
Corresponding Author's Email: stellaubbor@gmail.com: Phone number: +2348063967632

ABSTRACT
Water yam is a tuber crop that is valued for its nutrient composition amongst other yam cultivars. This study investigated the quality of shortbread biscuits produced from water yam and wheat flour blends. Shortbread biscuits were produced from seven formulations of composite flours made from wheat and two varieties of water yam (purple and white) at 30%, 50% and 60% ratios. Shortbread biscuits produced from 100% wheat flour served as control. The functional properties of the composite flours as well as the proximate composition, physical and sensory properties of the shortbread biscuits produced were determined. The functional properties of the flour blends such as oil absorption capacity, water absorption capacity, foam stability, gelatinization temperature and gelatinization time significantly ($p<0.05$) increased with increase in the incorporation of water yam flours. Foam capacity, emulsion capacity and wettability recorded highest for the control sample. Bulk density showed no significant difference ($p>0.05$) among all the flour blends. Shortbread biscuits differed significantly ($p<0.05$) in the proximate composition with the moisture content, crude protein, ash, carbohydrate and energy with the incorporation of water yam flours. The control recorded the highest values for crude fat (14.03%) and crude fiber (1.25%). The physical properties of the shortbread biscuits varied significantly ($p<0.05$) in terms of weight, thickness, height and breaking strength. The result of the sensory properties revealed a high general acceptability for all the shortbread biscuit samples. The result of this study deduced that up to 30% water yam substitution can be used for baked food products.

Keywords: Wheat, Water yam, Flour, Shortbread Biscuit, Sensory Properties.

INTRODUCTION

Biscuits are ready to eat oven-baked products produced from dough from the mixture of energy-rich flours, fat, sugar and sometimes, eggs (Burrier and Lucas, 2003). The components of shortbread biscuit make it an energy-dense snack which necessitates its enrichment with other protein rich ingredients (Warinporn and Geoffery, 2018).

Water yam is a valuable tuber in tropical regions whose fibre and mineral contents characterizes it as a functional food (Wireko-Manu *et al.*, 2013). They are highly perishable due to their high water content, therefore, processing it into flour is one cost effective way to extend its shelf life (Wireko-Manu *et al.*, 2013; Agemo and Raheem, 2019).

Wheat (*Triticum aestivum*), is one of the most important crops grown around the world. It is usually processed into various types of foods for human consumption due to its ease of handling (Lance and Garren, 2002). The high gluten content of wheat flour makes it very suitable flour in baking bread, biscuits and other yeasted products (Dvorak, 2009).

The main objective of this present study was to evaluate the quality of shortbread biscuits produced from water yam-wheat flour blends

MATERIALS AND METHODS

Sources of Raw Materials

The wheat seeds were purchased from Ubani Main Market in Umuahia, while the water yam tubers were procured from National Root Crops Research Institute (NRCRI) Umudike, all in Abia State, Nigeria.

Production of water yam flour

Water yam flour was produced according to the method described by Udensi *et al.* (2008). The water yams tubers were peeled, washed (in clean water), diced into pieces of 1.5mm thickness, blanched (in boiling water), oven dried (Shellab Model VWR = 1370G) at 60°C for 12 h and then milled into fine flour using a hammer mill (Tiger extruda 6.5 horse power). The flour obtained was sieved (250µm mesh size) and packaged in a transparent polyethylene bag and stored at room temperature (23^{o}C) for further use.

Production of wheat flour: The method described by Peter-Ikechukwu *et al.* (2017) was adopted in the production of wheat flour. The wheat grains were sorted, washed (in clean water) and drained of water using a perforated plastic bowl. The clean wheat grains were oven dried (Gallenkemp, 300 Plus, England) at 60ºC for 8 h, milled using hammer mill (HMC-HM6630, China) and sieved (250µm mesh size) to obtain wheat flour that was packaged in a polyethylene bag and stored at room temperature (23^{o}C) for further use.

Shortbread Biscuit Production from water yam and wheat composite flour

Shortbread biscuits were produced according to the method described by Darman *et al.* (2020). The ingredients used include: margarine (150g), sugar (100g), egg (35g), salt (2g), milk flavour (2g), vanilla flavour (2g). Using an electric mixer (Model 28a-Bl England), margarine and sugar was creamed until fluffy. Exactly 250g flour was added to the mixture and mixed continuously for 60 seconds to form dough. A mixture of egg, milk and vanilla flavour was added to the dough and thoroughly mixed until stiff dough was formed. The dough was rolled out, cut into shapes of uniform thickness and baked in a pre-heated oven at 190^{o}C for 15 min. The shortbread biscuit was allowed to cool and then packaged in a transparent polyethylene.

Table 1: Formulation of Composite Flours from water yam and wheat

Sample	WTF	PWY	WHY
101	100	0	0
102	70	30	0
103	70	0	30
104	50	50	0
105	50	0	50
106	40	60	0
107	40	0	60

Keys: WTF = Wheat flour, PWY = Purple water yam, WHY = White water yam
101 = 100% whole wheat flour (100:0:0)
102 = 30% purple water yam flour: 70% wheat flour (30:70:0)
103 = 70% wheat flour: 30% white water yam flour (70:30:0)
104 = 50% purple water yam flour: 50% wheat flour (50:50:0)
105 = 50% white water flour: 50% wheat flour (50:50:0)
106 = 60% purple water yam flour: 40% wheat flour (60:40:0)
107 = 60% white water flour: 40% wheat flour (60:40:0)

Determination of Functional Properties of Water yam and Wheat Composite Flour

The bulk density, oil absorption capacity, water absorption capacity, foam capacity and stability, emulsion capacity, wettability, gelatinization temperature and gelatinization time of the flour samples were determined according to the methods described by Owuka (2018).

Determination of Proximate Composition and energy value of the Shortbread Biscuit Samples

The proximate composition including; moisture content, ash, crude fat, crude fibre, crude protein, carbohydrate contents (by difference) and energy value (using Atwater factors) of the shortbread biscuit samples were determined according to the method described by Onwuka (2018).

Determination of Physical Properties of the Shortbread samples

The physical properties including: weight, thickness, height and breaking strength were determined according to the method described by Bala *et al*. (2015).

Determination of Sensory Properties of the Shortbread Samples

The method described by Iwe (2014) was adopted in the evaluation of the sensory properties of the shortbread biscuit samples. A total of 25 trained and untrained panelists performed the sensory test to determine the appearance, taste, crispness, texture, and general acceptability of the shortbread biscuits on 9-point Hedonic scale (1 = dislike extremely and 9 = like extremely). All shortbread biscuit samples were coded and presented to panelists on a tray in individual booths to avoid bias. A questionnaire describing the quality attributes of the shortbread biscuits was given to each panelist. The panelists were provided with portable water to rinse their mouth between evaluations prior to briefing them about the sensory test and calling them randomly to perform the sensory assessment.

Statistical Analysis

All the data collected were subjected to analysis of variance (ANOVA) of a completely randomized design using the SPSS procedure version 20.0 for personal computers. Treatment Means was separated using Duncan multiple range test at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSIONS

Functional Properties

The results of the functional properties of flour blends of water yam and wheat are presented in Table 2. The bulk The oil absorption capacity ranged from 1.76- 2.52g/ml. There were significant differences ($p<0.05$) among the samples in terms of oil absorption capacity except for samples 103(70% wheat flour: 30% white water yam flour (70:30:0)) and 104(50% purple water yam flour: 50% wheat flour (50:50:0)) while sample 102(30% purple water yam flour: 70% wheat flour (30:70:0)) had the least value of oil absorption capacity. High oil absorption capacity enhances flavour, mouth feel and dough quality in food products (Iwe *et al*., 2017). The composite flour with 50% purple water yam flour: 50% whole wheat flour recorded the highest oil absorption capacity (2.52%). The oil absorption capacity values (1.76- 2.52g/ml) obtained in this study were significantly ($p<0.05$) higher from the values (1.30 – 1.56g/ml) recorded by Chandra *et al.* (2015) for wheat-rice-potato composite flours.

The water absorption capacity ranged from 0.94- 2.33g/ml. Sample 105(50% white water flour: 50% wheat flour (50:50:0)) recorded the highest water absorption capacity while sample 102(30% purple water yam flour: 70% wheat flour (30:70:0)) had the least. Water absorption capacity represents the ability of a product to associate with water under conditions where water is limiting such as dough and batters in order to maintain freshness in baked product (Okpala *et al.*, 2013). Interestingly, Olapade and Akinyanju, (2014) recorded water absorption capacity value range of 1.26 - 1.64 g/ml for composite flours from water yam and soybean. His result is in variation with the result of this present study in terms of water absorption capacity. The maximum value of water absorption capacity obtained in this study was higher than that obtained by Olapade in his research. The high value of water absorption capacity as recorded for sample 105 could probably be said that the flour blends contain more hydrophilic constituents. The sample 105 (50% white water flour: 50% wheat flour (50:50:0)) with the highest water absorption capacity obtained in this study indicates that

density of the flour blends ranged from 0.82-0.85g/100g. Sample 104 (50% purple water yam flour: 50% wheat flour (50:50:0)) recorded the lowest value (0.82g/100g) while sample 107 (60% white water yam flour: 40% wheat flour (60:40:0)) had the highest value (0.85g/100g). However, there was no significant difference ($p>0.05$) between all the flours in terms of bulk density. This could be attributed to uniform particle size (250μm) particles obtained during the production of the flour samples. Bulk density is important in determining the packaging requirement, material handling and application in food industry (Falade and Okafor, 2014). The bulk density which is dependent on particle size and moisture content describes the relative volume of packaging material required and the mixing quality of a particulate matter without the influence of any compression (Chandra *et al.*, 2015). they will be useful in the formulation of foods such as sausage, dough, produced cheese and bakery products (Chandra *et al*., 2015).

The foam capacity of the water yam-wheat flour blends ranged from 8.75-22.33%. Sample 104(50% purple water yam flour: 50% wheat flour (50:50:0)) recorded the highest foam capacity while the control (100% wheat) had the lowest value. The low value recorded for the control (100% wheat flour) sample could be due to the nature of the protein denaturation. A decrease in the foaming capacity can be linked to protein denaturation (Butt and Battol, 2010).

The foam stability of the flour blends ranged from 101.91-113-41%. There were significant differences among the flour samples, in terms of the foam stability. Sample 104(50% purple water yam flour: 50% wheat flour (50:50:0)) recorded the highest value of foam stability while sample 105(50% white water flour: 50% wheat flour (50:50:0)) had the least value. This further explains the range of values (101.91% -113.41%) obtained for foam stability of the flour samples which are significantly higher than the values (1.94-13.40) obtained by Chandra *et al.* (2015) for composite flours.

The emulsion capacity of the flour blends of water yam and wheat ranged from 22.00-58.00%. There were significant differences ($p<0.05$) among the flour blends except for flour samples produced from 100% wheat flour (control) and 103(70% wheat flour: 30% white water yam flour (70:30:0), which recorded the highest score for emulsion capacity. It was observed that the emulsion capacity decreased with increase in the proportion of water yam especially purple water yam which, but increased as the level of wheat flour increases. This could be due to the protein in wheat being surface active agents which can form and stabilize the emulsion by creating electrostatic repulsion on oil droplet surface. The range of values obtained for emulsion capacity in this study was higher than 18.57-46.36% reported by Elochukwu *et al*. (2019) for high quality cassava, toasted bambara groundnut and roasted cashew kernel flour blends. According to Hoque *et al*. (2009), high emulsion activity is an indication that the flour will yield quality products due to the improved ease of handling and can also serve as an excellent emulsifier in various foods.

The wettability of the water yam-wheat flours ranged from 1.08 to 3.00 min/sec. The composite flours produced from 50% purple water yam flour and 50% whole wheat flour had the lowest wettability rate which implies that it will dissolve in water faster than 100% wheat flour which recorded the highest wettability rate. There were significance differences ($p<0.05$) among the wettability of the composite flours. The difference in the wettability of the flour blends could be due to the variability in their chemical composition. Wettability is the time required for a given amount of flour to be wetted. The ability of food flours or powder to disperse is largely dependent on their wettability capacity (Offia-Olua *et al*., 2019). High wettability as exhibited by the control sample could be attributed to the crude fiber content. This suggests that the flour sample will disperse more slowly in water than other flour samples with lower value of wettability (Ubbor and Akobundu, 2009).

The gelatinization temperature of the flour blends ranged from 45.00-75.00^{O}C. The highest gelatinization temperature (75^{0}C) was recorded for the composite flour produced from 50% white water yam flour and 50% wheat flour (sample 105) and this could be due to an extensive rupturing of the starch granules under heat (Awuchi, 2019). Gelatinization temperature is influenced by the amount of loose starch granules available in the sample (Ubwa *et al*., 2012). It could be explained that flour produced from sample 106 (60% purple water yam flour: 40% wheat flour (60:40:0)) has higher loose starch granules compared to other flour samples since this study shows that it has lower gelatinization temperature (Ubwa *et al*., 2012). The least gelatinization temperature obtained in flour produced from sample 106 (60% purple water yam flour: 40% wheat flour (60:40:0)) implied that it will require lesser heat energy and costs.

The gelatinization time is the time required for the amylose content of the starch granules to leach out. Values obtained in this study ranged from 0.39 to 1.32 min/sec with composite flour produced from 30% purple water yam flour: 70% wheat and that produced from 30% white water yam flour: 70% whole wheat flour recording the highest (1.32 min/sec) while the lowest (0.39 sec) gelatinization time was observed in sample 102(30% purple water yam flour: 70% wheat flour (30:70:0)).

Table 2: Functional Properties of Flour blends of Water yam and Wheat

Sample	Bulk Density (g/100g)	Oil Absorption Capacity (g/ml)	Water Absorption Capacity (g/ml)	Foam Capacity (%)	Foam Stability (%)	Emulsion Capacity (%)	Wettability (min/sec)	Gelatinization Temperature (^{o}c)	Gelatinization Time (sec)
101	$0.83^a±0.03$	$2.04^c±0.03$	$1.31^d±0.02$	$8.75^a±0.03$	$102.92^d±0.02$	$58.00^a±1.73$	$3.00^a±0.02$	$54.33^c±1.16$	$1.03^d±0.01$
102	$0.84^a±0.02$	$1.76^e±0.03$	$0.94^e±0.05$	$12.55^f±0.05$	$102.82^d±0.02$	$52.10^c±0.00$	$2.55^b±0.01$	$61.67^b±2.89$	$1.32^b±0.02$
103	$0.85^a±0.04$	$2.52^a±0.02$	$2.12^b±0.02$	$16.32^e±0.02$	$113.41^a±0.01$	$57.40^a±0.17$	$1.43^d±0.00$	$74.00^a±2.65$	$0.39^e±0.02$
104	$0.82^a±0.02$	$2.52^a±0.03$	$1.93^c±0.03$	$22.33^a±0.03$	$106.71^b±0.02$	$54.50^b±0.35$	$1.08^g±0.01$	$61.00^b±1.00$	$1.45^a±0.03$
105	$0.84^a±0.02$	$2.02^c±0.03$	$2.33^a±0.03$	$17.64^b±0.02$	$101.91^e± 0.0$	$45.83^e±2.80$	$2.02^c±0.01$	$75.00^a±1.73$	$1.24^c±0.02$
106	$0.84^a±0.02$	$2.12^b±0.02$	$1.25^b±0.02$	$14.55^e±0.02$	$102.99^d±0.02$	$22.00^c± 0.10$	$1.37^e±0.01$	$45.00^d±2.00$	$1.27^c±0.02$
107	$0.85^a±0.03$	$1.92^d±0.02$	$1.94^c±0.03$	$15.34^d±0.04$	$105.40^c±0.36$	$49.20^d±0.17$	$1.13^f±0.00$	$52.00^c±2.00$	$1.04^d±0.02$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$),

Keys: 101 = 100% wheat flour (100:0:0)
102 = 30% purple water yam flour: 70% wheat flour (30:70:0)
103 = 70% wheat flour: 30% white water yam flour (70:30:0)
104 = 50% purple water yam flour: 50% wheat flour (50:50:0)
105 = 50% white water flour: 50% wheat flour (50:50:0)
106 = 60% purple water yam flour: 40% wheat flour (60:40:0)
107 = 60% white water yam flour: 40% wheat flour (60:40:0)

Proximate Analysis

The results of the proximate analysis of the shortbread biscuits are presented in Table 3.

The moisture content of the shortbread biscuit samples ranged from 2.57-5.10%.
Shortbread produced from sample 103(70% wheat flour: 30% white water yam flour (70:30:0)) recorded the lowest moisture content which is an indication of a long shelf life as microbial activity will be minimal (Awuchi, 2019).

The crude protein contents of all the shortbread biscuits ranged from 11.02% to 12.04%. The shortbread biscuit samples produced from 50% purple water yam flour: 50% wheat flour(sample 104), recorded the highest crude protein content (12.04%) while sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) had the lowest. There were significant differences ($p<0.05$) among the shortbread biscuit samples. It was observed that the protein content of the shortbread biscuits increased with equal blends of purple water yam and wheat flour. This is an indication that both purple water yam and wheat contributed to the protein content of the shortbread biscuit samples. The low protein value recorded for shortbread biscuit produced from sample 107 could be attributed to the fact that white water yam contains lower amount of protein comparable to purple water yam. The result of the protein content of the samples was significantly higher than values (4.54-9.87%) obtained by Ogidi *et al.* (2017) for water yam and this can be attributed to the wheat content of the composite flour used in this study, which has been reported to contain significant amount of protein (Kumar *et al.,* 2011).

The fat content of the shortbread biscuits ranged from 9.35-14.03%. Shortbread biscuit produced from 100% wheat flour (control) recorded the highest value for fat, while sample 107(60% white water yam flour: 40% wheat flour (60:40:0)). The result revealed significant reduction in fat content as the proportion of both purple and white water yam flour increases. It could be due to the fact that water yam which is a tuber crop is not a good source of fat. A high fat content predisposes the product to rancidity and also increase its energy value (Fasasi, 2009). Shortbread biscuit with lower fat is an indication that they will be less prone to rancidity particularly if kept under conditions that will not facilitate it.

The crude fibre content of the shortbread biscuit samples ranged from 0.52-1.28%. Shortbread biscuits produced from samples 101(100% wheat flour) and 102(30% purple water yam flour: 70% wheat flour (30:70:0)) recorded the highest crude fibre, while shortbread biscuits produced from sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) had the least. There were significant differences ($p<0.05$) among the shortbread biscuits except for samples 103(70% wheat flour: 30% white water yam flour (70:30:0)) and 104(50% purple water yam flour: 50% whole wheat flour (50:50:0) which did not differ significantly ($p>0.05$) among each other. The result revealed increased fibre content as the proportion of wheat flour increases. This could be probably because wheat contains some amount of fibre which is higher than that of water yam. Fibre plays a vital role in human nutrition as it increases feacal bulk and lowers gastric cholesterol (Agomuo *et al.,* 2011). Shortbreads produced in this study recorded low crude fibre contents (0.52 to 1.28%). According to Awuchi (2019), diets low in fibre is undesirable as they have been associated with diseases of the colon like pile, appendicitis and cancer.

The ash content of the shortbread biscuits ranged from 2.01-2.65%. Shortbread biscuits produced from sample104 (50% purple water yam flour: 50% wheat flour (50:50:0)) recorded the highest value for ash content while sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) had the least value. High value of ash content recorded for sample 104 is an indication that both wheat and purple water yam flours contributed to the ash content of the shortbread biscuit. It was observed that ash content of the shortbread biscuits decreased as the proportion of white water yam increases. The progressive decrease in ash content as observed in shortbread biscuits produced from blends of white water yam could be attributed that white water yam used in this study possesses low ash content. There were significant differences ($p<0.05$) in ash content of the shortbread biscuits samples produced. However, the ash content values (2.01-2.65%) recorded for shortbread biscuit samples in this study is higher than the values (1.35 to 2.10 %) reported by China *et al*. (2020) for ash content of cookies produced from wheat/cooking banana flour blends. The ash content of a food product gives a rough estimation of the mineral content of that food product (Iwe *et al*., 2016).

The carbohydrate content of the shortbread biscuits ranged from 65.96-73.20%. Shortbread biscuits produced from samples 106(60% purple water yam flour: 40% wheat flour (60:40:0)) and 107(60% white water yam flour: 40% wheat flour (60:40:0) recorded the highest values for carbohydrate (72.61 and 73.20% respectively) and were not significantly different ($p>0.05$) among each other. The carbohydrate content of the shortbread biscuits were significantly high and this is an indication that the shortbreads are rich sources of energy. It was observed that all shortbread biscuits produced from flour blends of water yam recorded higher carbohydrate values than the control (100% wheat flour). The high values of carbohydrate obtained in shortbread biscuits produced from samples 106 and 107 could probably be attributed to the fact that both white and purple water yam possess higher carbohydrate content than wheat. This implies that shortbread biscuits produced from samples 106 and 107 (60% purple water yam flour: 40% wheat flour (60:40:0) and 60% white water yam flour: 40% wheat flour (60:40:0) respectively) will contribute more in maintenance of the plasma glucose level, sparing the body protein from being easily digested, prevention of the use up of protein and provision of energy to the body cells compared to other bread samples (Onimawo *et al*., 2019). In contrast, the least value of carbohydrate obtained in shortbread biscuits produced from the control (100:% wheat flour) indicated that it will be good for diabetic patients that require low carbohydrate diets.

The energy value of the shortbread biscuits was relatively high and ranged from 421.03-436.96kcal. Shortbread biscuits produced from samples 103(70% wheat flour: 30% white water yam flour (70:30:0)), 101 (100% wheat flour (100:0:0)) and 104(50% purple water yam flour: 50% wheat flour (50:50:0)) recorded the highest energy value and were not significantly difference among each other, while sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) had the lowest value. It was observed that most shortbread biscuits that have high proportion of wheat flour possess higher energy values. This could probably be because wheat flour recorded the highest fat content comparable to the other samples in this study. Using AT Water factor in calculating the energy available from food, fat has double the number of grams compared to that used for carbohydrate and protein which could be the reason for the increased value for energy as recorded for the control. However, the energy values obtained in this study were lower than the value (454.1 Kcal) reported by Darman *et al*. (2020) for shortbread made from wheat flour substituted with 70% sorghum flour.

Table 3: Proximate Compositions and Energy value of the Short Bread Biscuit Samples.

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Sample	Moisture content(%)	Crude Protein content (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)	Carbohydrate (%)	Energy Value (kcal)
101	$5.03^{a} \pm 0.04$	$11.21^{c} \pm 0.02$	$14.03^{a} \pm 0.03$	$1.25^{a} \pm 0.05$	$2.52^{b} \pm 0.02$	$65.96^{d} \pm 0.39$	$434.94^{a} \pm 1.74$
102	$5.10^{a} \pm 0.56$	$11.64^{b} \pm 0.55$	$13.08^{b} \pm 0.07$	$1.28^{a} \pm 0.02$	$2.57^{b} \pm 0.03$	$66.33^{d} \pm 1.04$	$429.58^{b} \pm 2.73$
103	$2.57^{c} \pm 0.35$	$11.06^{c} \pm 0.06$	$12.34^{d} \pm 0.02$	$1.11^{b} \pm 0.02$	$2.51^{c} \pm 0.01$	$70.41^{b} \pm 0.38$	$436.95^{a} \pm 1.36$
104	$3.50^{b} \pm 0.35$	$12.04^{a} \pm 0.02$	$12.57^{c} \pm 0.03$	$1.15^{b} \pm 0.02$	$2.65^{a} \pm 0.05$	$68.09^{c} \pm 0.03$	$433.65^{a} \pm 1.78$
105	$4.80^{a} \pm 0.30$	$11.85^{ab} \pm 0.05$	$12.05^{e} \pm 0.05$	$1.05^{c} \pm 0.03$	$2.47^{c} \pm 0.02$	$67.78^{c} \pm 0.26$	426.96 ± 1.56
106	$2.73^{c} \pm 0.57$	$11.96^{ab} \pm 0.03$	$10.01^{f} \pm 0.02$	$0.65^{d} \pm 0.03$	$2.04^{d} \pm 0.05$	$72.61^{a} \pm 0.62$	$428.36^{b} \pm 2.32$
107	$3.90^{b} \pm 0.36$	$11.02^{c} \pm 0.02$	$9.35^{g} \pm 0.03$	$0.52^{e} \pm 0.02$	$2.01^{d} \pm 0.02$	$73.20^{a} \pm 0.34$	$421.03^{c} \pm 1.49$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

KEY:

101 = 100% wheat flour (100:0:0)
102 = 30% purple water yam flour: 70% wheat flour (30:70:0)
103 = 70% wheat flour: 30% white water yam flour (70:30:0)
104 =50% purple water yam flour: 50% wheat flour (50:50:0)
105 =50% white water yam flour: 50% wheat flour (50:50:0)
106 = 60% purple water yam flour: 40% wheat flour (60:40:0)
107 = 60% white water yam flour: 40% wheat flour (60:40:0).

The physical properties of the shortbread biscuit samples are presented on Table 4. The result of this study revealed significant differences ($p<0.05$) amongst the parameters (weight, thickness, height and breaking strength) investigated.

The weight of the shortbread biscuits ranged from 14.12 to 24.76g. Sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) recorded the highest value for weight while sample 104(50% purple water yam flour: 50% wheat flour (50:50:0)) had the least, Increase in weight was observed as the addition of water yam increased. This could be due to high carbohydrate content arising from incorporation of both white and purple water yam flours as confirmed in Table 3. Significant differences ($p<0.05$) existed among the shortbread biscuit samples. The values obtained in this study were similar to the values (15.40 to 17.20g) obtained by Agu *et al*., 2007 on wheat and African bread fruit.

In this study thickness of the shortbread biscuits ranged from 11.70-13.60cm. Shortbread biscuits produced from sample 105 (50% white water yam flour: 50% wheat flour (50:50:0)) had the highest value for thickness while shortbread biscuits produced from sample 107 (60% white water yam flour: 40% wheat flour (60:40:0).) had the least. The differences in the thickness could be due to the quality of starch in wheat. The result revealed that shortbread biscuit samples produced from flour blends with increased level of wheat were thicker than those produced from increased level of both purple and white water yam. There was significant differences ($p<0.05$) among the shortbread biscuits. The values of thickness obtained from this study is similar to the range of values for thickness (12.50-13.50 mm) reported by Igbabul *et al*. (2015) for cookies produced from wheat flour and fermented *Afzelia africana* flour. According to Peter-Ikechukwu *et al*. (2017), resistance to stress increases with increase in thickness. Therefore, shortbread with high values for thickness will withstand stress when compared to those with low values for thickness.

The height of the biscuit samples ranged from 5.20 to 6.65cm. Shortbread biscuit produced from sample 107(60% white water yam flour: 40% wheat flour (60:40:0)) recorded the highest value for height while samples 101(100% wheat flour (100:0:0)) and 102(30% purple water yam flour: 70% wheat flour (30:70:0)) had the least values (5.20 cm) and were not significantly different between each other. Values of height increased as the level of white water yam increased. This could be attributed to the carbohydrate content of the flour blends of sample 107(60% white water yam flour and 40% wheat flour) which must have aided large expansion of the shortbread biscuit samples during baking. The height of biscuits plays a role in determining consumer preference because consumers are more likely to go for biscuits with higher height when presented with a low height and high height biscuits (Kolawole *et al*., 2018).

The breaking strength values obtained in this study ranged from 7.96-9.23g. The high breaking strength observed in shortbread biscuit produced from 30% purple water yam flour: 70% wheat flour(sample 102) and control(100% wheat flour), while the least value of was recorded for shortbread biscuit sample produced from 60% purple water yam flour: 40% wheat flour (60:40:0). The reduction in breaking strength could be due to the carbohydrate/starch content of the purple water yam which may not be as hard or strong like that of wheat. The high values as observed in shortbread biscuit samples containing high level of wheat flour(samples 101 and 102), could be attributed to high gluten content in wheat flour which aids in binding it strongly**.** Breaking strength refers to the force required to break cookies and is dependent on the interaction between the proteins and starch hydrogen bonds (Ikuomola *et al*., 2017).

Sensory Properties of the shortbread biscuit samples

The sensory properties of the shortbread biscuits are presented in Table 5. There was no significant difference ($p>0.05$) in the attributes evaluated (appearance, taste and texture and general acceptability), except for crispness. The highest value for crispness was recorded for shortbread biscuit samples produced from sample 107(60% white water flour: 40% wheat flour (60:40:0)), while the control (100% wheat flour) sample had least. The result revealed that all shortbread biscuits samples produced from flour blends of white water yam and wheat were crispier than those produced from flour blends of purple water yam and wheat. The crispness of the shortbread biscuit samples increased with increase in the level of white water yam flour (Table 5). This could probably be attributed to the texture of the shortbread biscuit samples as observed in Table 5 of this study, where all the shortbread biscuit samples produced with flour blends of white water yam and wheat recorded higher values for texture than those produced from flour blends of purple water yam and wheat.

Browning reactions during baking has been reported to improve consumer acceptance rate of a food product as a result of improved taste, aroma and appearance (Piqueras-Fiszman, and Spence, 2015; Okwunodulu *et al*., 2019). Therefore, this explains the high general acceptability of all the biscuits in terms of taste and appearance. The range of values (7.23-7.86) recorded for general acceptability in this study is similar to the values (5.55-7.87) obtained by Oluwamukomi *et al.* (2011) for biscuits produced from cocoyam and wheat flours. The range of values obtained for texture in this study fell within the range of values (6.17 to 8.00) reported by Temesgen *et al.* (2015) for cookies produced from wheat-orange fleshed sweet potato flour.

Table 4: Physical properties of the Shortbread Biscuit Samples.

Sample	Weight (g)	Thickness (mm)	Height (cm)	Break Strength (g)
101	$16.55^{cd}\pm0.92$	$12.50^{c}\pm0.21$	$5.20^{c}\pm0.14$	$8.82^{b}\pm0.04$
102	$20.81^{bc}\pm0.98$	$13.00^{ab}\pm0.00$	$5.20^{c}\pm0.00$	$9.23^{a}\pm0.40$
103	$16.21^{cd}\pm0.44$	$12.50^{c}\pm0.07$	$5.65^{ab}\pm0.21$	$8.43^{bc}\pm0.58$
104	$14.12^{d}\pm1.86$	$12.00^{cd}\pm0.14$	$5.45^{b}\pm0.07$	$8.04^{c}\pm0.13$
105	$22.17^{b}\pm3.82$	$13.60^{a}\pm0.07$	$5.73^{ab}\pm0.18$	$9.11^{a}\pm0.21$
106	$17.43^{c}\pm3.78$	$12.50^{c}\pm0.07$	$5.43^{b}\pm0.25$	$7.96^{d}\pm0.13$
107	$24.76^{a}\pm0.51$	$11.70^{d}\pm0.17$	$6.65^{a}\pm0.07$	$9.01^{ab}\pm0.06$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$),

Key: 101 = 100% wheat flour (100:0:0)

102 = 30% purple water yam flour: 70% wheat flour (30:70:0)

103 = 70% wheat flour: 30% white water yam flour (70:30:0)

104 = 50% purple water yam flour: 50% wheat flour (50:50:0)

105 = 50% white water yam flour: 50% wheat flour (50:50:0)

106 = 60% purple water yam flour: 40% wheat flour (60:40:0)

107 = 60% white water yam flour: 40% wheat flour (60:40:0).

Table 5: Sensory properties of the shortbread biscuits samples.

Sample	Appearance	Taste	Crispness	Texture	General Acceptability
101	7.45[a] ±1.76	7.59[a] ±1.14	7.45[ab] ±0.91	6.77[a] ±1.41	7.73[a] ±1.07
102	7.32[a] ±0.99	7.68[a] ±0.83	7.55[ab] ±0.91	7.23[a]±1.41	7.73[a] ±0.76
103	7.64[a] ±0.79	7.59[a] ±1.18	7.55[ab] ±0.85	7.27[a] ±1.48	7.86[a] ±0.88
104	7.23[a] ±1.44	7.00[a] ±1.27	6.77[c] ±1.57	6.95[a] ±1.55	7.41[a] ±1.18
105	7.23[a] ±1.44	7.14[a] ±0.94	7.41[ab] ±0.95	7.36[a] ±1.13	7.73[a] ±1.07
106	7.14[a]±1.32	7.18[a] ±1.05	6.91[bc] ±0.86	7.05[a]±0.99	7.23[a] ±1.19
107	7.36[a] ±1.29	7.41[a] ±1.14	7.68[a]±0.78	7.36[a] ±1.32	7.59[a] ±0.85

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (P<0.05).

Keys: 101 = 100% wheat flour (100:0:0)
102 = 30% purple water yam flour: 70% wheat flour (30:70:0)
103 = 70% wheat flour: 30% white water yam flour (70:30:0)
104 =50% purple water yam flour: 50% whole wheat flour (50:50:0)
105 =50% white water yam flour: 50% wheat flour (50:50:0)
106 = 60% purple water yam flour: 40% wheat flour (60:40:0)
107 = 60% white water flour: 40% wheat flour (60:40:0)

CONCLUSION AND RECOMMENDATIONS

The result obtained in this study revealed that quality shortbread biscuits could be produced from blends of water yam and wheat flours. From the result of the sensory properties, shortbread biscuits produced from the various blends of water yam flour competed favourably with the control sample (100%) wheat and there was no significant difference amongst the biscuit samples. This is an indication that water yam could serve as a good replacement of wheat flour in the production of confectionaries. In this study, it was observed that the addition of water yam increased the nutrient composition (crude protein, ash and carbohydrate) of the shortbread biscuits. Moreover, the shortbread biscuits with water yam flour exhibited lower moisture and fat content than the control (100% wheat), which is a good indication that they would have longer shelf life than the control since they would not be prone to microbial attack and rancidity. This study had revealed that the addition of water yam yielded a product which will serve as good source of energy. This study also revealed that the shortbread biscuits produced from composite flours of water yam possess better physical attributes such as increased weight, thickness and height as compared with the control(100% wheat), which is preferred by the consumers. It is therefore recommended that up to 30% substitution of wheat flour with water yam flour be adopted in the production of shortbread and other baked food products. This will not only add value to the locally grown tuber "water yam" but will also act as a cost-effective way to reduce the cost implication in the use of wheat flour for confectionery. Moreover, being a highly perishable tuber, it would be converted into more stable and accepted form, thereby preventing postharvest losses.

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Conflict of Interest

The authors declare no conflict of interest.

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