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EVALUATION OF BISCUITS PRODUCED FROM WHEAT (*Triticum aestivum*), TIGER NUT (*Cyperus esculentus*) AND ORANGE FLESHED SWEET POTATO (*Ipomea batatas*) FLOURS

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ABSTRACT

Biscuits are ready-to-eat nutritious baked snacks that are available in different shapes and sizes. One of the problems that militate against food security in developing countries such as Nigeria is postharvest loss and underutilization of locally cultivated food crops. This study aimed at evaluating the quality of biscuits produced from wheat, tiger nut and orange fleshed sweet potato flours. Wheat flour was substituted with tiger nut and orange fleshed sweet potato (OFSP) flours for the production of biscuits. While constant 10% tiger nut flour was used in each of the six formulations, the OFSP flour portions were increased from 5 to 30%. A 100% wheat flour served as control. The functional properties of the flours, proximate composition, energy value, vitamin contents, physical and sensory properties of the biscuits were determined using standard methods. The result of the functional properties showed no significant differences ($p>0.05$) in the bulk densities and gelatinization temperatures of the flour blends. There was significant ($p<0.05$) reduction in the moisture content of the biscuit samples made from the composite flours compared to the control biscuit sample. Inclusion of tiger nut and sweet potato flour led to increase in the fat, fibre, carbohydrate content and energy values of the biscuit samples. The pro-vitamin A and vitamin C increased as the proportion of orange sweet potato increased and in all the composite biscuits containing tiger nut flour. There were no significant differences ($p>0.05$) in the thickness, spread ratio and volume of the biscuits. The results of the sensory properties showed general acceptability in the biscuits produced from the flour blends and they compared favourably with the control. It was concluded that addition of tiger nut and OFSP flour improved some of the nutrient components of the biscuits.

Keywords: Pro-vitamin A deficiency, wheat, tiger nut, indigenous crops, flour

INTRODUCTION

Biscuits are low moisture baked ready-to-eat snacks made from unleavened dough and are usually consumed among all age groups in many countries particularly in parts of the world where there is prevalence of protein and calorie deficiency (Chinma and Gernah, 2007; Olaoye *et al.,* 2007; Okaka, 2009).

Wheat flour is the most versatile and principal raw material utilized in the production of baked foods however, its cultivation is limited to some parts of the world due to the climatic conditions hence, has necessitated its importation in those parts of the world (Iwe, 2015). Consequently, a general increase in the demand for baked foods has been recorded over time which has translated to an increase in wheat importation in wheat-poor parts of the world hence, a subsequent increase in cost of baked foods (CSA, 2011; FAO, 2022).

The nutritional composition of baked foods is vital in meeting nutrient needs of the consumers (WHO, 2010). Biscuits produced from wheat are energy-dense therefore, requires additional nutrients to meet basic nutrient needs and help curb the prevalence of most deficiencies (Bruins *et al.,* 2018).

It has been reported that vitamin A deficiency is one of the most prevalent micronutrient malnutrition amongst children and infants in the world recording adverse impairment in their growth and development and can be fatal in the absence of timely intervention (Tenagashaw *et al.,* 2017; Zhao *et al.,* 2022). Therefore, fortification of biscuits using pro vitamin A rich indigenous foods will not only curb the prevalence of vitamin A deficiency, but will also significantly reduce the cost of wheat importation while promoting the utilization of indigenous crops (Noort *et al*., 2022).

On the other hand, orange fleshed sweet potato (*Ipomoea batatas*) contains a diverse array of vitamins and minerals with potential nutritional benefits to meet nutrient needs and reduce vitamin A deficiency (VAD) and under-nutrition (Jaarsveld*et al*., 2006). Studies have also shown that Orange fleshed sweet potato flour is richer in β-carotene than wheat flour (Gebreegziabher *et al*., 2013; Teferra *et al*., 2015).

Also, Tiger nut (*Cyperus esculentus*) is a lesser known and underutilized crops potentially valuable as human and animal food (Belewu and Belewu, 2007). According to Adejuyitan (2011), tiger nut has been identified to maintain a balance between population growth and agricultural productivity particularly in the tropical and sub-tropical areas of the world. However, Nigeria grows staple crops other than wheat such as tiger nut, orange fleshed sweet potato, cassava, yam and lots of other cereals apart from wheat, which can be used for bakery foods. It would therefore be of economic advantage if wheat flour can be replaced with flours from tubers, legumes and cereals with high local production in Nigeria, hence reducing the reliance on its importation and thus enhance the industrial utilization of local crops. Replacing relative proportion of wheat flours with orange fleshed sweet potato and tiger nut could have an advantage on the nutritional component of the biscuits

The objectives of this current study were to: (1) evaluate the quality of biscuits produced from composite flours of wheat, tiger nut and orange fleshed sweet potato. (2) determine the functional properties of composite flours of wheat, tiger nut and orange fleshed sweet potato (3) determine the proximate composition, vitamin content, physical and sensory properties of the biscuits.

MATERIALS AND METHODS

Source of raw materials

The wheat grains (plate 1), tiger nut(plate 2) and all other baking ingredients used for the production of the biscuitss were purchased from Umuahia Main Market. The Orange fleshed sweet potato tubers(plate 3) were procured from National Root Crops Research Institute (NRCRI), Umudike, all in Abia state, Nigeria.

Production of wheat flour

The method as described by Ndife *et al*. (2014) was used in the production of wheat flour. The wheat kernels were sorted, washed in portable water and steeped in water (2:1) for 4 h. The water was then drained using a perforated plastic sieve and the wheat kernels dried at 60°C for 6 h in a Uniscope laboratory hot air drying oven (model SM9023) and milled into flour with an attrition mill (model SK-30-SS). The resultant flour was sieved through a 0.4 mm sieve mesh and packaged in a transparent hermetically sealed cellophane paper and stored at room temperature (24°C) until needed.

Production of tiger nut flour

The method described by Adejuyitan *et al.* (2009) was adopted for the production of tiger nut flour. The tiger nut seeds were sorted, cleaned, washed in portable water, drained using a perforated plastic sieve and oven dried at 60°C for 3 h using Uniscope laboratory hot air drying oven (model SM9023). The dried tiger nut seeds were milled into flour with an attrition mill (model SK-30-SS) and then sieved through a 0.4mm mesh sieve. The resultant fine flour was packaged in a transparent hermetically sealed cellophane paper and stored at room temperature (24°C) until needed.

Production of orange fleshed sweet potato flour

The method as described by Singh *et al*. (2008) was used in the production of orange sweet potato flour. The wholesome orange fleshed sweet potato tubers were sorted, washed, peeled and sliced to 1-1.5mm thickness with stainless steel kitchen knife. The sweet potato slices were blanched in boiling water for 2 minutes, drained using plastic sieve and dried at 60°C for 24 h in Uniscope laboratory hot air drying oven (model SM9023). The dried potato slices were milled into flour with an attrition mill (model SK-30-SS) and subsequently sieved through a 0.4 mm sieve mesh. The resultant fine flour was packaged in a transparent hermetically sealed cellophane paper and stored at room temperature (24°C) until needed.

Composite Flour Formulation

Wheat, tiger nut and orange fleshed sweet potato flours were blended to obtain six (6) composite samples (Table 1). Each formulation was mixed using Argos food blender (XB, 9165) to obtain homogenous mixture. A 100% wheat flour served as the control.

Table 1: Formulation of the Composite Flour used for the cookies production

Sample Code	Flours (%)		
	Wheat	Tiger nut	Orange Fleshed Sweet Potato
202(100Wf (control)	100	-	-
101(85Wf10Tn5Sp)	85	10	5
102(80Wf10Tn10Sp)	80	10	10
103(75Wf10Tn15Sp)	75	10	15
104(70Wf10Tn20Sp)	70	10	20
105(65Wf10Tn25Sp)	65	10	25
106(60Wf10Tn30Sp)	60	10	30

Where; Wf = wheat flour; Tn = tiger nut flour; Sp = orange fleshed sweet potato flour

Production of biscuits

In the production of biscuits, the method described by Ayo *et al*. (2018) was used. The ingredients used include: flour (500 g), fat (200 g), sugar (150 g), whole egg (125 ml), water (75 ml), salt (2.5 g), baking powder (5 g), flavor (5 ml), and nutmeg (5 g). The fat (margarine) and sugar were creamed to a smooth consistency; eggs and milk were added and mixed until homogeneous mixture was obtained. The dry ingredients; flour, baking powder, nut meg and vanilla flavor were mixed together and added to the cream followed by mixing to form dough. The dough was kneaded to uniform thickness, rolled out thinly on a flat table and cut into desired sizes and shapes of 6 cm diameter with biscuit cutter. They were placed in greased baking trays and baked at 190°C for 20 minutes. The hot baked biscuits were allowed to cool, packaged in hermetically sealed plastic container and stored at room temperature until needed.

Analyses

Functional Analysis: The flour samples were analysed for functional properties (water/oil absorption capacity, bulk density, wettability and emulsion capacity) using the methods described by Onwuka, (2018).

Chemical Analysis: The proximate composition, caloric value, Beta-carotene (pro-vitamin A) content of the cookies was determined using the methods described by Onwuka (2018).

Physical Properties: The weight, diameter and thickness were determined according to the methods described by Ayo *et al*. (2007). The spread ratio and break strength were determined according to the method described by Bala *et al.* (2015).

Statistical Analysis: The data obtained was subjected to analysis of variance of a completely randomized design using Statistical Package for the Social Sciences (SPSS) version 21.0 for personal computer while treatment means were separated using Duncan's multiple range test at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSIONS

Functional Properties

The results of the functional properties of the flour blends are presented in Table 2.

The bulk density of a food is one of the determinants of the required packaging for that food (Awuchi *et al.*, 2019). There was no significant difference ($p>0.05$) in the bulk density amongst all the flour samples. Values recorded for bulk density (0.73-0.85) in the study were greater than values (0.762 – 0.820g/cc) reported by Chandra *et al.* (2015) for bulk density of composite flour produced from wheat, rice, green gram and potato flours. High bulk density is desirable for packaging. The oil and water absorption capacities were observed to increase with increase in the orange fleshed sweet potato portion in the formulations. This could be attributed to high carbohydrate contents of each flour since carbohydrates have been reported to greatly influence the water absorption capacity of foods (Anthony *et al*., 2014). Higher values for oil and water absorption capacity were also observed in all the composite flours containing tiger nut flour. Interestingly, the results showed no variation in the gelatinization temperature of the composite flour. However, values (72.00 – 74.00^{0}C) recorded for gelatinization temperature of the composite flours in this study were than the values (56.50 to 75.00°C) recorded by Ubbor *et al*. (2022) on composite blends of wheat:acha:orange sweet potato flours. Gelatinization temperature is the temperature at which the gelatinization of starch takes place. The gelatinization time ranged from 1.14 – 1.57 min/sec with flour sample containing 20% orange fleshed sweet potato recording the highest. The emulsion capacity increased with increased proportions of the composite flour. Similar findings were recorded by Chandra *et al.* (2015) and Ohizua *et al.* (2017). The range of values (32.33-52.21g/ml) for emulsion capacity recorded in this study was significantly higher than that (10.05 – 18.86g/ml) recorded by Ajani *et* al. (2016) for composite flour produced from wheat and breadfruit. There were no significant differences (p>0.05) in the foam stability of the flour blends. The result of the foam stability ranged from 102.96-105.44%. According to Ganesa (2021), foam stability is an important functional property of proteins essential in many food formulations.

Proximate Composition of the biscuit samples

The proximate composition of the biscuits is presented in Table 3.

There were significant (p<0.05) differences in the proximate composition and energy value of the biscuit samples. The moisture content significantly reduced as the proportion of orange sweet potato increased (Table 3). This can probably be attributed to the water binding capacity of the starch molecules present in the tiger nut and OFSP flours (Teferra *et al*., 2015). Igbabul *et al.* (2018) reported similar results for moisture content of cookies produced from flour blends of wheat, sweet detar and moringa.

The control recorded the highest protein content (9.94%); a clear indication that tiger nut and orange fleshed sweet potatoes may not be reliable sources of protein. Interestingly, the protein content recorded in this study was significantly higher than that (4.4 – 6.4%) recorded by Adeyeye (2015) for cookies produced from flour blends of maize grains and sweet potato tuber.

The fat content increased with increase in wheat flour substitution. The observed increase in fat content with increase in orange fleshed sweet potato flour portions in the biscuit samples, points to a possible high oil absorption capacity of the flour and presence of tiger nut flour. Similar trend in fat content was recorded by Ikumola*et al.* (2017) for cookies as the substitution of wheat with malted barley bran flour increased in the wheat-malted barley bran flour blends.

Table 2: Functional Properties of composite flour of wheat, tiger nut and orange fleshed sweet potato

Sample code	BD (g/cm^3)	WAC (g/ml)	OAC (g/ml)	GET (ºC)	GT (min/sec)	WETT (min/sec)	EC (%)	FS (%)
202	$0.73^a±0.04$	$1.81^g±0.01$	$1.92^g±0.03$	$72.50^a±3.54$	$1.22^c±0.01$	$7.18^a±0.01$	$32.33^g±0.04$	$105.44^a±2.11$
101	$0.75^a±0.00$	$1.88^f±0.01$	$1.97^f±0.01$	$72.50^a±3.54$	$1.38^b±0.01$	$3.22^c±0.01$	$41.42^f±0.02$	$103.91^{ab}±0.01$
102	$0.77^a±0.01$	$1.98^e±0.01$	$2.12^e±0.01$	$73.00^a±2.83$	$1.56^a±0.01$	$3.32^b±0.03$	$44.05^e±0.04$	$104.79^{ab}±0.01$
103	$0.78^a±0.00$	$2.17^d±0.01$	$2.27^d±0.01$	$72.00^a±1.41$	$1.14^e±0.01$	$2.23^d±0.03$	$46.82^d±0.03$	$101.91^{ab}±0.03$
104	$0.79^a±0.01$	$2.28^c±0.01$	$2.44^c±0.03$	$74.00^a±1.41$	$1.57^a±0.01$	$1.35^f±0.01$	$48.64^c±0.03$	$104.54^{ab}±0.03$
105	$0.81^a±0.01$	$2.37^b±0.02$	$2.67^b±0.01$	$74.00^a±4.24$	$1.41^b±0.01$	$2.14^e±0.02$	$50.03^b±0.03$	$102.96^{ab}±0.03$
106	$0.85^a±0.13$	$2.48^a±0.02$	$2.85^a±0.04$	$73.50^a±2.01$	$1.18^d±0.00$	$2.22^d±0.01$	$52.21^a±0.01$	$102.96^{ab}±0.01$

$^{a-g:}$ Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscript letters are significantly different (p < 0.05)

Keys: BD= Bulk density; WAC=water absorption capacity; OAC= oil absorption capacity; GT=gelatinization temperature; WETT= wettability; GET= gelatinization time; EC= emulsion capacity; FS= foam stability Wf= wheat flour; Tn = tiger nut flour; Sp= orange fleshed sweet potato flour

202(100Wf)=100% wheat flour(Control)

101(85Wf10Tn5Sp)=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour;

102(80Wf10Tn10Sp)=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour;

103(75Wf10Tn15Sp)=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour,

104(70Wf10Tn20Sp)=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour;

105(65Wf10Tn25Sp)=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour;

106(60Wf10Tn30Sp)=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour.

The fibre content of foods have been shown to aid digestibility of foods and reduced cancer risks (Wardlaw and Kessel, 2005). The significant increase in fibre content in the biscuits upon the inclusion of tiger nut and OFSP flours indicates that they contain relatively higher fibre content than wheat flour. Similarly, Adeola and Ohizua (2017) reported an increase in the crude fibre content of cookies produced from flour blends of unripe cooking banana, pigeon pea and sweet potato as the pigeon pea flour portions increased.

The ash content is basically considered the mineral content of that food (Iwe *et al*., 2016). The control sample(100% wheat) recorded the highest ash content(1.88%) implying a richer mineral content than biscuits produced from the composite flour.

Biscuits are conventionally energy-dense foods therefore, will contain high carbohydrate content (Adeola and Ohizua, 2017). Although the carbohydrate contents were relatively high across all the samples, the control sample still recorded a higher carbohydrate(71.08%) content (Table 4). The higher fibre and fat content in the biscuits produced from the composite flour explains their lower carbohydrate values.

The energy value of the biscuits significantly ($p>0.05$) increased from 362.33-385.90 kcal for samples 202(control-100% wheat and sample 106(60Wf10Tn30Sp-60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour. This could be attributed to the fat content(Table 3) of the sample which is double the protein and carbohydrate which made up the energy value of the biscuits.Previous researchers opined that besides carbohydrate content of food products like cookies, protein and fat contents also contribute to their energy value (Ikuomola *et al*. (2017).

Table 3: Proximate composition and caloric values of biscuits produced from the composite flour of wheat, tiger nut and orange fleshed sweet potato

Sample code	Proximate composition (%)						Energy value (Kcal)
	Moisture	Crude Protein	Crude fat	Crude Fibre	Ash	Carbohydrate	
202	12.38^{a}±0.03	9.94^{a}±0.03	4.25^{g}±0.01	0.47^{g}±0.01	1.88^{a}±0.01	71.08^{a}±0.01	362.33^{f}±0.01
101	11.81^{b}±0.01	9.28^{b}±0.03	10.26^{f}±0.01	4.48^{f}±0.03	1.81^{ab}±0.01	61.70^{g}±0.06	382.24^{e}±0.08
102	10.83^{c}±0.04	9.11^{c}±0.01	10.33^{e}±0.03	4.72^{e}±0.03	1.75^{ab}±0.44	62.77^{f}±0.02	384.97^{c}±0.41
103	10.39^{d}±0.01	9.06^{c}±0.01	10.62^{d}±0.02	4.93^{d}±0.01	1.71^{ab}±0.01	63.10^{e}±0.01	385.68^{ab}±0.08
104	10.13^{e}±0.04	8.44^{e}±0.06	10.76^{c}±0.03	5.21^{c}±0.01	1.61^{ab}±0.01	64.01^{d}±0.11	385.31^{bc}±0.01
105	9.84^{f}±0.06	8.40^{e}±0.01	10.83^{b}±0.04	5.47^{b}±0.01	1.75^{ab}±0.01	64.22^{c}±0.09	384.05^{d}±0.43
106	9.22^{g}±0.03	8.58^{d}±0.01	10.92^{a}±0.03	5.69^{a}±0.01	1.44^{b}±0.01	64.82^{b}±0.04	385.90^{a}±0.05

$^{a-g}$: Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscript letters are significantly different ($p < 0.05$)

Keys: Wf= wheat flour; Tn = tiger nut flour; Sp= orange fleshed sweet potato flour
202(100Wf)=100% wheat flour(Control)
101(85Wf10Tn5Sp)=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour;
102(80Wf10Tn10Sp)=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour;
103(75Wf10Tn15Sp)=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour,
104(70Wf10Tn20Sp)=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour;
105(65Wf10Tn25Sp)=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour;
106(60Wf10Tn30Sp)=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour

Vitamin content of the biscuit samples

The pro-vitamin A (β-carotene) and vitamin C (ascorbic acid) contents of the biscuits are presented in Table 4. The significant increase in the beta-carotene content of the biscuits with increase in the OFSP flour potions underlines the rich pro-vitamin A content of OFSP. Being a biofortified crop, OFSP has been reported to contain a rich amount of beta carotene to help curb Vitamin A deficiency in vitamin A deficient vulnerable populations of the world (Maru, 2017; Satheesh and Workneh, 2019).

These further highlights the potentials of biscuits produced in this study to provide a significant amount of pro-vitamin A to the consumer when consumed. The ascorbic acid content of the biscuits increased as the proportions of OFSP increased. Being a heat labile compound, the baking process would have been responsible for significantly reducing the ascorbic acid content of the biscuits (Pessu *et al.*, 2020). This explains the relatively low levels of vitamin C content of the biscuits recorded in this study. However, values obtained for vitamin C content (24.49 – 44.80µg/100g) of biscuits in this study were lower than those (10.89 – 76.69mg/100g) reported by Pessu *et al*. (2020) for vitamin C content of biofortified sweet potato products. It was also observed that biscuit samples containing 10% of tiger nut had higher vitamins compared to the control sample(100% wheat flour).

Physical properties of the biscuit samples

The results of the physical properties of the biscuit samples are presented in Table 5. The results showed no significant differences ($p>0.05$)amongst the biscuit samples in terms of thickness, spread ratio and volume (Table 5). The weight of the biscuits ranged from 4.27(sample 202-100% wheat-control) -7.82g(sample 106) with all the biscuits produced from the composite flours having higher weights. This could be related to the higher bulk densities of tiger nut and orange fleshed sweet potato flours which have been shown to increase weight in baked foods (Awuchi *et al*., 2019). Nonetheless, sample 104 recorded a relatively highest diameter value(3.57cm) than other biscuits made from the composite flours but was not significantly from the control sample(3.55 cm).

Table 4: Vitamin content (µg/100g) of biscuits produced from the composite flour of wheat, tiger nut and orange fleshed sweet potato

Sample code	Pro-vitamin A (β-carotene)	Vitamin C
202	3.08^{g}±0.01	24.49^{f}±0.01
101	6.92^{f}±0.03	30.70^{e}±0.14
102	9.06^{e}±0.01	36.0d±0.00
103	12.33^{d}±0.04	38.09^{c}±0.01
104	15.85^{c}±0.02	40.12^{b}±0.03
105	18.63^{b}±0.01	40.12^{b}±0.03
106	20.65^{a}±0.01	44.80^{a}±0.00

$^{a-g}$: Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscript letters are significantly different ($p < 0.05$)

Keys: Wf= wheat flour; Tn = tiger nut flour; Sp= orange fleshed sweet potato flour
202(100Wf)=100% wheat flour(Control);
101(85Wf10Tn5Sp)=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour;

102(80Wf10Tn10Sp)=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour;
103(75Wf10Tn15Sp)=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour,
104(70Wf10Tn20Sp)=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour;
105(65Wf10Tn25Sp)=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour;
106(60Wf10Tn30Sp)=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour.

The density values ranged from 0.70 to 1.32 g/cm^3 with the control sample recording the lowest value; an indication that the fibre content of tigernut and orange fleshed sweet potato flours could have contributed to the increased density in biscuits produced from composite flours (Jemziya and Mahendran, 2017). Similar results were reported by Jemziya and Mahendran (2017) for the density of cookies produced from composite flours made from sweet potatoes and wheat flour. Breaking strength values increased from 25-40% replacement of wheat flour with tigernut and orange fleshed sweet potato flours (Table 5).

Sensory Properties of the biscuit samples

The sensory properties of the biscuit samples are presented in Table 6.

There was no significant difference (p>0.05)the colour. The colour on the other hand, which according to Surkan *et al.* (2009) is an essential sensory attribute for consumers when making purchasing decisions on a food product, was observed to deepen and change from a creamy to a deep brown colour with the increase in the proportion of OFSP. This was probably due to the browning reaction that occurred during baking in addition to the orange colour of the OFSP flour as the preference score also increased with increase in the OFSP portions.

There were no significant differences (P>0.05) in the taste and texture of the biscuits produced, implying that the composite biscuit samples compared favourably with the control in terms of taste and texture irrespective of the partial replacement of wheat flour with tiger nut and OFSP flours. Significant differences (p<0.05) existed amongst the biscuits in terms of crispiness. However, biscuits produced from partial substitution of wheat flour with 10% tiger nut and 5% OFSP flours was most preferred in terms of crispiness(7.05). All the biscuits were generally accepted and there was no significant difference (p>0.05)amongst them in terms of general acceptability. This further showed that the biscuit composite compared favourably with the conventional biscuit produced from 100% wheat flour.

Table 5: Physical properties of biscuits produced from the composite flour of wheat, tiger nut and orange fleshed sweet potato

Sample code	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio	Volume (cm^3)	Density (g/cm^3)	Breaking strength(g)
202	$4.27^{d}\pm0.01$	$3.55^{a}\pm0.01$	$0.62^{a}\pm0.01$	$5.73^{a}\pm0.16$	$6.14^{a}\pm0.09$	$0.70^{e}\pm0.00$	$8.13^{b}\pm0.00$
101	$5.00^{d}\pm0.22$	$3.50^{ab}\pm0.03$	$0.60^{a}\pm0.01$	$5.89^{a}\pm0.12$	$5.72^{a}\pm0.03$	$0.88^{de}\pm0.04$	$8.13^{b}\pm0.00$
102	$5.36^{cd}\pm0.23$	$3.51^{ab}\pm0.04$	$0.59^{a}\pm0.04$	$5.75^{a}\pm0.19$	$5.69^{a}\pm0.29$	$0.95^{cd}\pm0.01$	$8.13^{b}\pm0.01$
103	$6.78^{ab}\pm0.62$	$3.45^{b}\pm0.06$	$0.62^{a}\pm0.02$	$5.61^{a}\pm0.09$	$5.74^{a}\pm0.40$	$1.18^{ab}\pm0.02$	$10.28^{a}\pm0.00$
104	$6.48^{bc}\pm0.78$	$3.57^{a}\pm0.03$	$0.61^{a}\pm0.01$	$5.76^{a}\pm0.04$	$6.11^{a}\pm0.05$	$1.07^{bc}\pm0.12$	$10.28^{a}\pm0.01$
105	$6.41^{bc}\pm0.71$	$3.54^{ab}\pm0.06$	$0.60^{a}\pm0.00$	$5.90^{a}\pm0.10$	$5.91^{a}\pm0.19$	$1.09^{bc}\pm0.15$	$10.28^{a}\pm0.00$
106	$7.82^{a}\pm0.35$	$3.53^{ab}\pm0.01$	$0.61^{a}\pm0.01$	$5.78^{a}\pm0.14$	$5.95^{a}\pm0.11$	$1.32^{a}\pm0.02$	$10.28^{a}\pm0.00$

Values in the same column with different superscript letters are significantly different (p < 0.05)
Keys: Wf= wheat flour; Tn = tiger nut flour; Sp= orange fleshed sweet potato flour
202(100Wf)=100% wheat flour(Control);
101(85Wf10Tn5Sp)=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour
102(80Wf10Tn10Sp)=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour
103(75Wf10Tn15Sp)=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour
104(70Wf10Tn20Sp)=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour
105(65Wf10Tn25Sp)=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour
106(60Wf10Tn30Sp)=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour

Table 6: Sensory evaluation of biscuits produced from composite flour of wheat, tiger nut and orange fleshed sweet potato

Sample code	Appearance	Aroma	Taste	Texture	Crispness	Overall Acceptability
202	$6.15^{c}\pm1.32$	$6.60^{a}\pm1.35$	$6.95^{a}\pm1.15$	$7.00^{a}\pm1.43$	$6.65^{ab}\pm1.60$	$7.35^{a}\pm0.99$
101	$6.25^{b}\pm1.29$	$6.35^{a}\pm1.09$	$6.65^{a}\pm1.14$	$6.50^{a}\pm1.28$	$7.05^{a}\pm1.61$	$7.15^{a}\pm1.09$
102	$6.45^{ab}\pm1.28$	$6.85^{a}\pm1.23$	$6.35^{a}\pm1.42$	$6.50^{a}\pm1.38$	$6.25^{ab}\pm1.12$	$7.20^{a}\pm1.06$
103	$6.35^{ab}\pm1.14$	$6.85^{a}\pm1.04$	$6.95^{a}\pm0.94$	$6.55^{a}\pm1.27$	$6.65^{ab}\pm1.81$	$7.20^{a}\pm0.89$
104	$6.70^{ab}\pm1.42$	$6.95^{a}\pm1.28$	$6.85^{a}\pm1.69$	$6.55^{a}\pm1.28$	$5.45^{b}\pm1.93$	$7.25^{a}\pm0.79$
105	$7.10^{ab}\pm1.29$	$6.65^{a}\pm1.31$	$6.85^{a}\pm1.39$	$6.40^{a}\pm1.19$	$6.00^{ab}\pm1.75$	$7.35^{a}\pm1.18$
106	$7.15^{a}\pm1.09$	$7.00^{a}\pm1.45$	$6.80^{a}\pm0.95$	$6.50^{a}\pm1.73$	$5.85^{ab}\pm2.06$	$7.20^{a}\pm1.28$

$^{a-g:}$ Values are means ± standard deviation of duplicate determinations.
Values in the same column with different superscript letters are significantly different (p < 0.05)
Keys: Wf= wheat flour; Tn = tiger nut flour; Sp= orange fleshed sweet potato flour
202(100Wf)=100% wheat flour(Control)
101(85Wf10Tn5Sp)=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour
102(80Wf10Tn10Sp)=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour
103(75Wf10Tn15Sp)=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour

104(70Wf10Tn20Sp)=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour
105(65Wf10Tn25Sp)=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour
106(60Wf10Tn30Sp)=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour.

CONCLUSION

In conclusion the results of this study have shown that enriched and acceptable biscuits can be produced from partial replacement of wheat flour up to 40% substitution with tiger nut and OFSP flours. A greater preference in appearance of the biscuits was observed as the OFSP flour portions increased. The biscuits produced in this study compared favourably with the control (100% wheat), a clear indication that up to 40% substitution of wheat flour with other flours produced from indigenous crops is feasible and also, economically gainful while meeting nutrientional needs of the nation. Apart from the reduction in moisture content which is an indication of long shelf life stability, the addition of tiger nut and orange fleshed sweet potato enhanced the, carbohydrate, fiber, energy value and vitamin contents of the biscuits. This is an indication that the composite biscuit will proffer solution to malnutrition. It was therefore recommended that more research can be channeled towards the optimization of some underutilized crops in mitigating targeted nutrient deficiencies and easing economic burdens resulting from wheat importation.

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Plates 4-6: Raw materials for the study (wheat, tiger nut and orange fleshed sweet potato tuber)

Plate 1: wheat grains

Plate 2: Tiger nut seeds

Plate 3: orange fleshed sweet potato tuber

Plates 4-6: Flours from wheat, tiger nut and orange fleshed sweet potato

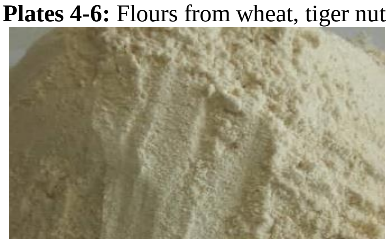

Plate 4: wheat flour

Plate 5: Tiger nut seeds flour

Plate 6: orange fleshed sweet potato flour

Plates 7-13: Biscuits from the different composite flours(samples 202, 101-106)

Plate 7: sample 202

Plate 8: sample 101

Plate 9: sample 102

Plate 10: sample 103

Plate 11: sample 104

Plate 12: sample 105

Plate 13: sample 106

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