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Proximate Composition, Functional Properties and Sensory Evaluation of Cracker Biscuit from Okara Fortified Plantain-Sorghum Flour Blend

Ilelaboye N. O.* & Jesusina T. I.
Department of Science Laboratory Technology, Federal Polytechnic, Ilaro. Ogun State, Nigeria
Corresponding author:nasir.ilelaboye@federalpolyilaro.edu.ng

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Abstract

Biscuits produced from 10 different composite flour blends of plantain-sorghum fortified with or without okara and the composite flours were analysed for their proximate composition, food energy and functional properties. Also, sensory evaluation of the biscuits was done. The flours contained moisture (5.50 -7.70%), ash (1.50-2.40%), fat (1.90-2.89%), protein (2.70-6.00%), fibre (2.50-3.90%), carbohydrates (80.20-83.80%) and food energy (362.00-368.89 Kcal/100g). The mean values were: bulk density (0.46-0.58g/mL), water absorption capacity (177.82-236.95%), oil absorption capacity (92.59- 141.22%), swelling power (5.87-9.97g/g), solubility index (36.60-50.53%) and wettability (45.88-132.62 s). Increasing the proportion of sorghum flour in the blend resulted in a rise in bulk density, swelling power, solubility index, and reduction in water absorption capacity, oil absorption capacity, and wettability. While the addition of okara caused increases in all the functional properties except the solubility index. The biscuits contained moisture (6.10-8.200%), ash (2.80-3.20%), fat (3.20-4.40%), protein (2.90-6.50%), fibre (2.70-4.00%), carbohydrates (74.67-80.79%) and food energy (363.27-370.47 Kcal/100g). Evaluation of sensory attributes suggested that the flour blend having 72.5% plantain flour, 22.5% sorghum flour and 5.0% okara flour produced the most acceptable biscuit. It was concluded that composite flour made from a blend of plantain and sorghum flours fortified with okara could replace wheat flour for the production of nutritious and organoleptic acceptable biscuit.

Keywords: Composite flour; Biscuit; Functional properties; Sensory evaluation; Proximate composition.

Citation

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1. Introduction

Crackers are unsweetened, salty, thin and crisp biscuits, with little or no sugar and fat content. Biscuits are an inexpensive common cereal food product eaten throughout the world, due to its digestive and vital important dietary values, eating effortlessness, and obtainability in different shapes, palate and lengthier shelf-life compared to other processed foods (Kulkarini, 1997; Hussein, Hussein & El Damohery, 2006).

Soymilk residue (okara) is *a* non-traditional soy protein food obtained as a byproduct during the production of milk and tofu from soya bean, and of low economic value, consumed by animal regardless of its high nutrient content (Kulkarini, 1997). Okara contains about 27% protein (dry basis), 10% oil, 42% insoluble fibre and 12% soluble fibre, and a superior protein efficiency ratio (O'Toole, 1999). Okara has been described as a suitable replacement for wheat flour in the production of cookies or bread (Puechkamut & Thiewtua, 2006; Puechkamut, 2007; Puechkamut & Phewnim, 2011; Puechkamut & Panyathitipong, 2012).

Plantain (*Musa paradisiaca,* a family *Musaceae)* is a tropical plant native to India, and a foremost essential source of energy food in the tropical parts of Africa It is known as '*Ogede agbagba'* (Yoruba), *'Ayaba'* (Hausa) and '*Ogadejioke'* (Igbo). Most plantain foods are eaten as boiled, fried or roasted. Also, unripe plantain flour can serve as raw material for making varieties of baked food. Nutritionally, plantain fruit contains carbohydrates, minerals, amino acids, fibre, and carotenoids and this composition makes it an excellent material for the formulation.

Sorghum (*Sorghum vulgare* and *Sorghum bicolor*) is a critical staple cereal food and feed - crop for large populations in Africa and India, where nearly all the produce is used directly as human food (Sanni, Onitilo, Oyewole, Keiths, & Westby, 2004). Sorghum can also be made into malted foods, beverages, and beer, and its flour has higher levels of lipids, ash, crude fibre, and protein.

Composite flour is a blend of varying proportions of flours from several crops with or without wheat flour, and in addition to enhancing nutritional composition will also improve the desired functional properties of the end product (Adeyemi & Ogazi, 1985; Shittu, Raji, &Sanni, 2007). Composite flours have served as valuable ingredients in the production of baked goods.

Over the years, wheat flour has been the main raw material for the production of baked foods, but the high cost associated with wheat importation, informed the need for production of inexpensive, functional composite flours using readily available agricultural materials with the suitable nutritional value of proteins, carbohydrates, fibres, fat and ash contents. The objectives of this study, therefore, were to determine the proximate composition and energy value of cracker biscuit produced from okara fortified plantain-sorghum composite flour and the flours' functional properties.

2. Materials and methods

All the ingredients used for the production of flours in this study were bought from Sayedero market, Ilaro, Ogun State, Nigeria.

2.1 Preparation of plantain flour

The green plantain fingers (20 kg) were thoroughly washed and sundried for 30 min. The fruits were manually peeled, cut into the water to prevent browning and then oven-dried at 80^oC for 6 hr. The dried slices ground with a hammer mill (Bentall Superb, Model 200L 09) into powder of 75µm size and kept in sealed plastic containers at room temperature for further use.

2.2 Preparation of sorghum flour

Foreign bodies were removed from the sorghum grains (5 kg), then washed and subjected to open air-drying for 4 hr. The dried grains were pulverised with a hammer mill (Bentall Superb Model 200L 09) into a fine powder that passed through a 75µm mesh sieve and kept in airtight plastic containers at room temperature for further use.

2.3 Preparation of soybean residue (Okara) flour

Using Fukushima (1991) method, the spoilt soybean and debris were removed by floatation, followed by blanching at 100^oC for 25 min and dehulled. Using 5.0 L of water to 1 kg of dehulled cotyledons were wet-milled. The okara **(**soybean residue**)** separated from the milk by filtering the slurry through a muslin cloth, and oven-dried at 70^oC, milled and sieved through a 75µm mesh sie9ve and stored in airtight plastic containers in the refrigerator at 4^oC for further use.

2.4 Composite Flour Formulation

Ten different composite flour samples were formulated following the flour blends shown in Table 1.

Table 1. Percentage Composition of Plantain, Sorghum and Okara Flour

Sample	Plantain (%)	Sorghum (%)	Okara (%)	Total (%)
A	100	0	0	100

B	75	25	0	100
C	50	50	0	100
D	25	75	0	100
E	0	100	0	100
F	95	0	5	100
G	72.5	22.5	5	100
H	47.5	47.5	5	100
I	22.5	72.5	5	100
J	0	95	5	100

2.5 Production of cracker biscuit from the composite flour

Following the ingredient composition shown in Table 2, the cracker biscuit was prepared by mixing 3.48 g of yeast, 0.16 g of baking powder, and 2.02 g of salt in a bowl containing 50 ml of water, into which 100 g of the flour was added with shortening and kneaded to form a dough. The dough was later cut into the desired shape and baked at 170°C for 15 min.

Table 2. Ingredients Composition for Biscuit Production

Ingredient	Quantity
Composite flour	100g
Salt	2.02g
Fat	9.64g
Yeast	3.48g
Baking Powder	0.16g
Water	50ml

2.6 Chemical analysis

The proximate compositions of the flour blends were determined with the method of the Association of Official Analytical Chemist (AOAC, 1990), and Atwater factors were used to calculate the energy value (Ihekoronye & Ngoddy, 1985). The following functional properties of the flours were determined with appropriate standard methods: swelling power and solubility index (Takashi & Sieb, 1988), bulk density (Akpapunam & Markakis, 1981), water and oil absorption capacities (Okezie & Bello, 1988) and wettability (Onwuka, 2005).

2.7 Sensory evaluation

The biscuit samples were evaluated for a sensory attribute using the 9 points Hedonic scale quality analysis (Iwe, 2002). Twenty (20) amateur panellists selected from students and staff of the Federal Polytechnic, Ilaro, Ogun State, Nigeria, appraised the biscuit samples for colour, aroma, taste, aftertaste and overall acceptability, where 1 (one) corresponds to like extremely, and 9 (nine) corresponds to dislike extremely.

2.8 Statistical analysis

All determinations were performed in triplicate, and data analysed using one-way analysis of variance (ANOVA) and presented as the mean ± standard deviation. Duncan Multiple Range (DMR) test at $P \leq 0.05$ used to compare the mean (SPSS 16, 2008).

3. Results and Discussion

3.1 Chemical composition

The results of proximate compositions of the composite flours and the experimental biscuits are presented in Tables 3 and 4, respectively. Composition of the flours and the biscuits varied significantly (ph<0.05). The flours

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contained moisture (5.50-7.70%), ash (1.50-2.40%), fat (1.90-2.89%), protein (2.70-6.00%), fibre (2.50-3.90%), carbohydrates (80.20-83.80%) and food energy (362.00-368.89 Kcal/100g). The biscuits contained moisture (6.10-8.200%), ash (2.80-3.20%), fat (3.20-4.40%), protein (2.90-6.50%), fibre (2.70-4.00%), carbohydrates (74.67-80.79%) and food energy (363.27-370.47 Kcal/100g).

The moisture contents of the composite flour increased significantly ($p < 0.05$) with increasing sorghum flour inclusion and addition of okara powder. The low moisture content of the product improves its shelf stability and prevents deterioration due to microbial activities or chemical changes during storage (Shahzadi, Butt, Rehman, & Sharif, 2005; Akomolafe & Aborisade, 2007). The moisture content of biscuits produced from the composite flour is higher than that of wheat biscuit produce by (Ajibola, Oyerinde, & Adeniyan, 2015), recorded to be 3.65%, and this could be as a result of high moisture content of sorghum and okara in the composite flour.

Table 3: The Proximate Composition (%) and Energy (Kcal/100g) Values of the Okara Fortified Plantain-Sorghum Composite Flour

Sample*	Moistur	Ash	Fat	Protein	Fibre	Carbohydrate	Energy
A	$5.5^{a}±0.02$	$2.3^{e}±0.06$	$1.9^{a}±0.08$	$2.7^{a}±0.06$	$3.8^{g}±0.16$	$83.8^{i}±0.02$	$363.0^{ab}±0.0$
B	$6.0^{c}±0.09$	$2.0^{d}±0.08$	$2.1^{b}±0.05$	$2.9^{a}±0.28$	$3.3^{de}±0.1$	$83.4^{h}±0.05$	$365.3^{ab}±0.0$
C	$6.4^{d}±0.06$	$1.8^{c}±0.05$	$2.2^{bc}±0.06$	$3.9^{c}±0.05$	$3.0^{c}±0.11$	$82.7^{g}±0.06$	$363.5^{ab}±0.0$
D	$6.8^{e}±0.08$	$1.6^{ab}±0.0$	$2.2^{bc}±0.14$	$4.4^{de}±0.0$	$2.8^{b}±0.02$	$82.2^{f}±0.09$	$366.2^{a}±0.20$
E	$7.7^{g}±0.03$	$1.5^{a}±0.15$	$2.3^{cd}±0.12$	$5.6^{f}±0.09$	$2.5^{a}±0.07$	$80.4^{c}±0.05$	$364.7^{ab}±0.0$
F	$5.5^{a}±0.05$	$2.4^{e}±0.07$	$2.5^{de}±0.09$	$3.2^{b}±0.10$	$3.9^{g}±0.03$	$82.6^{g}±0.03$	$365.1^{ab}±0.0$
G	$5.8^{b}±0.10$	$2.0^{d}±0.11$	$2.6^{ef}±0.07$	$4.2^{cd}±0.1$	$3.6^{f}±0.04$	$81.6^{e}±0.04$	$366.2^{ab}±0.0$
H	$6.4^{d}±0.12$	$1.8^{c}±0.04$	$2.7^{fg}±0.02$	$4.6^{e}±0.13$	$3.4^{e}±0.09$	$81.1^{d}±0.12$	$367.2^{ab}±0.0$
I	$6.8^{e}±0.04$	$1.7^{bc}±0.1$	$2.8^{gh}±0.06$	$5.7^{fg}±0.15$	$3.2^{d}±0.05$	$80.2^{b}±0.11$	$368.9^{b}±0.06$
J	$7.4^{f}±0.07$	$1.6^{ab}±0.0$	$2.89^{h}±0.0$	$6.0^{g}±0.05$	$2.8^{b}±0.08$	$79.3^{a}±0.15$	$367.1^{ab}±0.0$

*Values are Mean± SD of triplicate determinations, and Mean values with different superscripts in the same column differ significantly at $p < 0.05$.

**Sample Key = A [[100P:0S]; B [75P: 25S]; C [50P: 50S] D [25P: 75S]; E [0P: 100S]; F [95P:0S:5K];G[72.25P:22.75S:5K];H[47.5P:47.5S:5K];I[22.75P:72.25S:5K];J[95S:0P:5K] P[Plantain Flour], S[sorghum Flour], K[Okara Flour]

Table 4. The Proximate Composition (%) and Energy (Kcal/100g) values of Biscuit Prepared from Okara Fortified Plantain-Sorghum Composite Flour

Sample**	Moisture	Ash	Fat	Protein	Fibre	Carbohydrates	Energy
A	$6.1^{a}±0.03$	$3.0^{d}±0.06$	$3.2^{a}±0.15$	$2.9^{a}±0.07$	$3.9^{ef}±0.06$	$80.8^{c}±.04$	$364.0^{b}±0.0$
B	$6.4^{bc}±0.0$	$2.9^{bc}±0.06$	$3.4^{bc}±0.11$	$3.4^{bc}±0.11$	$3.5^{d}±0.11$	$80.4^{c}±0.09$	$365.8^{f}±0.06$
C	$7.0^{d}±0.$	$2.9^{bc}±0.07$	$3.6^{de}±0.03$	$3.8^{c}±0.03$	$3.3^{c}±0.06$	$79.4^{c}±0.04$	$365.2^{e}±0.0$
D	$7.5^{e}±0.02$	$2.8^{ab}±0.03$	$3.7^{ef}±0.07$	$4.5^{d}±0.09$	$3.0^{b}±0.06$	$78.6^{bc}±0.11$	$370.5^{i}±0.1$
E	$8.2^{f}±0.05$	$2.8^{ab}±0.06$	$3.9^{g}±0.08$	$5.7^{f}±0.15$	$2.7^{a}±0.02$	$76.6^{ab}±0.144$	$364.7^{ab}±$
F	$6.3^{b}±0.10$	$3.0^{d}±0.01$	$3.5^{cd}±0.11$	$3.3^{b}±0.03$	$4.0^{f}±0.09$	$79.9^{c}±0.07$	$364.4^{c}±0.1$
G	$6.5^{c}±0.14$	$2.9^{bc}±0.03$	$3.8^{g}±0.13$	$4.3^{d}±0.04$	$3.8^{e}±0.02$	$78.7^{bc}±0.05$	$366.2^{h}±0.0$
H	$7.1^{d}±0.07$	$2.8^{ab}±0.03$	$3.3^{ab}±0.06$	$4.8^{e}±0.04$	$3.4^{cd}±0.0$	$78.6^{bc}±0.15$	$363.3^{a}±0.0$
I	$7.4^{e}±0.15$	$2.7^{a}±0.02$	$4.2^{h}±0.14$	$5.6^{f}±0.03$	$3.1^{b}±0.13$	$74.7^{a}±0.04$	$368.2^{i}±0.12$

J	8.2^{f}±0.08	2.8^{ab}±0.07	4.4^{i}±0.04	6.5^{g}±0.06	3.0^{b}±0.05	75.1^{a}±0.03	366.0^{g}±0.04

*Values are Mean± SD of triplicate determinations and Mean values with different superscripts in the same column differ significantly at $p < 0.05$.
**Sample key = A [[100P:0S; B [75P: 25S]; C [50P: 50S] D [25P: 75S]; E [0P: 100S]; F [95P:0S:5K]; G[72.25P:22.75S:5K]; H[47.5P:47.5S:5K]; I[22.75P: 72.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]

The ash contents of the flour blends and biscuits varied significantly (P < 0.05). With or without fortification with okara, the ash contents of the flour blends decreased progressively with increasing inclusion level of sorghum (Table 3). The ash contents of the experimental composite flours (1.50-2.40%) is within the 2.0% reported for wheat flour value (Nneka, & Charles, 2016). Ash content indicate a rough estimation of minerals content of the product, and sample F has the highest ash content of 2.40% which show that sample F has the highest mineral content. The ash contents of the biscuits decreased significantly with the inclusion of sorghum flour. However, there was no significant difference in the blends that had sorghum inclusion. The fortification of the flours with okara did not affect ash contents at each level of sorghum inclusion (Table 4). The ash content of biscuit produced by the composite flour ranged from 2.8 to 3.0% and are more than wheat biscuit ash content (2.31%.) made by (Ajibola et al., 2015). The inclusion of Okara has no impact on the ash content of biscuits produced with the fortified flour.

The result indicated that fat content increases significantly (P< 0.05) as the level of sorghum increased. Also, at every level of sorghum inclusion, fortification with okara significantly increased the fat content of the flour blends (Table 3). The lower the lipid value in the flour, the higher its storage ability by reducing the likelihood of rancidity and also caused low energy value of the product (Fasasi, 2009). The fat content of biscuits produced from the composite flours exhibited the same trend as their corresponding flours. Furthermore, the fat contents of the biscuits were lower than the fat content (14.39 %) of biscuit produced from wheat by Ajibola et al. (2015).
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The per cent protein of the composite flour and the biscuits varied significantly (P< 0.05) and they showed similar trends. With and without okara fortifications, protein contents increased as the level of sorghum increased in the flour blends and the biscuits. The results, therefore, seemed to suggest that fortification of the composite flour with Okara affected the flours positively. Also, at every level of sorghum inclusion, okara addition raised the protein contents. However, the range of protein contents obtained for the test composite flours (2.70-6.00%) (Table 3) is lower than that reported for wheat flour (10.12%) by Nneka et al., (2016). The protein content of the biscuit produced from the composite flour ranged from 2.9% to 6.5% in the present study (Table 4) are lower than the protein content (10.99 %) of biscuit produced from wheat by (Ajibola et al., 2015).

The fibre contents of the composite flours and biscuits decreased significantly (P< 0.05) with increasing sorghum inclusion level. Those composite flours and biscuits without okara fortification had higher fibre contents than those without added okara (Table 3). These observations might be attributed to the high fibre contents of plantain and okara (Kiin-Kabari & Giami, 2015). The fibre content of biscuit produced from the test composite flours ranged from 2.0 to 4.0% (Table 4) is higher than that (2.45%) found in wheat biscuit (Ajibola et al., 2015).

The per cent carbohydrate of the test composite flours was affected significantly (P<0.05) inclusion levels of sorghum and okara fortification. The carbohydrate contents decreased progressively as the inclusion level of sorghum increased. Also, okara fortification caused a reduction in the nutrient's contents (Table 3). The carbohydrate contents of the test composite flour in this study (80.20-83.80%) is higher than that of wheat (76.30%) recorded by Nneka et al. (2016). The carbohydrate content of biscuit produced from the composite flours ranged from 75.1 to 80.9%. The fortification of the composite flour to produce biscuit with Okara reduced its carbohydrate contents from 76.6 – 80.8% to 75.1-79.9% (Table 4).

The food energy value of the composite flour ranged from 366.2 to 368.89 kcal/100g. The fortification of the composite flour with Okara has a positive impact on the flour. With and without okara fortification, the energy contents of the flours were 363.0-364.7 Kcal/100g and 365.1-368.9 Kcal/100g, respectively. The energy value in this study (362.00-368.89 Kcal/100g) is lower than that reported for wheat (382.64 kcal/100g) by Nneka, et al. (2016). The energy content of biscuit produced from the composite flour ranged from 363.3 to 370.5 kcal/100g and is similar to that of Okoye et al. (2016). With and without okara fortification, the energy contents of the flours were 364.7-370.5 Kcal/100g and 363.3-368.2 Kcal/100g, respectively.

3.2 Functional properties

The results of the functional properties of the test composite flours are presented in Table 5. The functional properties of the test flours varied significantly ($p<0.05$). The mean values were: bulk density (0.46-0.58 g/mL), water absorption capacity (177.82-236.95%), oil absorption capacity (92.59-141.22%), swelling power (5.87-9.97g/g), solubility index (36.60-50.53%) and wettability (45.88-132.62 s). The results indicated that irrespective of the fortification with okara, bulk density and swelling power increased significantly as the sorghum inclusion level increased, while water absorption capacity, oil absorption capacity and wettability decreased progressively. However, fortification with okara remarkably increased all the of variables functional properties except for swelling power.

The range of bulk density values of the test composite flours was similar to bulk density reported by other workers (Abioye, Ade-Omowaye, Babarinde & Adesigbin, 2011; Kiin-Kabari, Eke-Ejiofor & Giami, 2015). Bulk density of flour is influenced by its particle size, and it is an indication of level porosity of the product. The cost and choice of the packaging material are a function of bulk density, and it governs the treatment and use of raw material in wet processing in the food industry (Iwe & Onalope, 2001; Adebowale, Sanni & Onitilo, 2008; Ajanaku, Ajanaku, Edobor- Osoh & Nwinyi, 2012).

Table 5. Effect of okara addition on the functional properties of the composite flour

Samples**	Bulk density (g/cm3)	Water Absoption Capacity (%)	Oil Absoption Capacity (%)	Swelling Power (g/g)	Solubility Index (%)	Wettability (secs)
A	0.46 ± 0.02^{a}*	233.28 ± 6.63^{i}	141.22 ± 8.65^{i}	6.48 ± 1.74^{b}	36.60±6.60	119.56±11.
B	0.49 ± 0.02^{b}	216.49 ± 4.17^{g}	129.46 ± 6.70^{g}	7.85 ± 0.89^{c}	36.88±8.30	95.72 ± 7.67^{g}
C	0.52 ± 0.04^{c}	208.22 ± 4.55^{e}	117.60 ± 6.45^{e}	8.23 ± 1.60^{d}	37.00±5.90	76.96 ± 6.67^{e}
D	0.54 ± 0.02^{d}	195.91 ± 1.42^{c}	100.85 ± 7.04^{c}	9.12 ± 0.94^{e}	37.22 ± 7.0^{6b}	52.33 ± 9.40^{c}
E	0.57 ± 0.03^{e}	$177.82\pm1O.73^{a}$	92.59 ± 3.46^{a}	9.97 ± 2.02^{f}	$37.433.23^{b}$	26.78 ± 2.13^{a}
F	0.47 ± 0.03^{ab}	236.95 ± 10.41^{j}	142.70 ± 4.35^{j}	5.87 ± 1.02^{a}	49.70±4.70	132.62±8.3
G	0.50 ± 0.04^{bc}	220.92 ± 9.42^{h}	131.38 ± 9.00^{h}	6.93 ± 1.47^{b}	49.93±5.40	108.29±6.0
H	0.53 ± 0.02^{cd}	211.84 ± 5.34^{f}	120.43 ± 5.92^{f}	7.60±1.03c	50.00±4.98	91.73 ± 5.56^{f}
I	0.55 ± 0.03^{de}	200.61 ± 3.18^{d}	103.73 ± 5.53^{d}	8.32 ± 1.53^{d}	50.35±6.30	68.11 ± 4.05^{d}
J	0.58 ± 0.01^{ef}	186.41 ± 2.12^{b}	96.53±4.49b	8.97 ± 1.85^{de}	50.53±8.13	45.88 ± 2.92^{b}

*Values are Mean± SD of triplicate determinations and Mean values with different superscripts in the same column differ significantly at $p < 0.05$.

**Sample Key = A [[100P:0S]; B [75P: 25S]; C [50P: 50S] D [25P: 75S]; E [0P: 100S]; F [95P:0S:5K]; G[72.25P:22.75S:5K]; H[47.5P: 47.5S:5K];I[22.75P:72.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]

Several workers had indicated that protein affects the water absorption capacity of food materials (Kiin-Kabari et al., 2015; Adebowale et al., 2008; Butt & Batool, 2010) and it explains the effect of the addition of okara, a protein-rich flour caused an increase in the water absorption capacity of the test composite flour. The rise in water absorption capacity of the blends can be useful in bakery products that requires hydration to improve dough handling characteristics. Also, increasing sorghum level in the flour blends caused a decline in the water absorption capacity due to the compactness of former's starch polymer structure (Adebowale et al., 2008; Oladipupo & Nwokocha, 2011).

Similarly, the oil absorption capacity of the test flours decreased with increase in the amount of sorghum in the blends. -The flours' proteins, which structure is made up of both hydrophilic and hydrophobic group has a positive influence on the oil absorption capacity of the flours (Jilngarmkusol, Hongsuwankul, Tananuwong, 2008). Therefore, sample F with high OAC will be good for the production of bakery products as it will retain flavour and increase the mouthfeel of the product (Adegunwa et al., 2017).

Protein content affects the swelling power of the sample since the protein in flour lowers the starch granules openness to water hence reducing the swelling power (Woolfe, 1992; Aprianita, Purwandari, Watson & Vasiljevic, 2009). Therefore, in this work, the sample with the smallest per cent protein has the highest swelling power 9.97±2.02 g/g while sample F's swelling power 5.87±1.02 g/g is the least. It has been reported that the swelling power shows the extent of associative forces within granule and depend on the ratio of amylose to amylopectin in the granule (Tester and Morrison, 1990, Moorthy and Ramanujam 1986). Abioye, et al. (2011) reported higher swelling power for 100% plantain flour (8.22 g/100 g) than the value obtained in this study (6.48±1.74 g/g). The difference in the values might be due to the variety of plantain used for the flour

The solubility of starch in most starch-based products is caused by leaching of starch amylose, which is enhanced by hydrolysis of starch to amylose during soaking (Numfor, Walter & Schwartz, 1998). The solubility index of the composite flour in the study varied significantly ($P<0.05$) from 36.60±0.60% to 50.53±0.00% as the level of sorghum in the blends increased and with the addition of okara flour. The higher the solubility index the better the reconstitution of the flour.

The wettability values ranged from 26.78±2.13 to 132.62±8.33 s. The wettability of the composite flours reduced as the level of sorghum increased in the blends; whereas, the addition of okara to the composite flours extended the wetting time of the flours. This results implied that plantain flour would take a longer time to absorb water than sorghum. The fortified composite flours took a longer period to sink in water, and this could be probably because okara must have changed the physical compositions of the plantain-sorghum flour and made it less susceptible to imbibe water (Oluwamukomi, Adeyemi, & Oluwalana, 2005).

3.3 Sensory evaluation

The sensory scores of the biscuit produced from okara fortified plantain-sorghum composite flour revealed significant differences in all the parameters evaluated. Panellists' ratings on the colour of biscuit indicated that sample C (50%plantain +50%sorghum without okara substitution) was the most acceptable with mean values of 4.60, while samples J (95%sorghum+5%okara) and F (95%plantain +5%okara) were partially acceptable with mean values of 2.75 and 3.20, respectively. The most acceptable biscuit sample in terms of texture and aroma was sample D (25% plantain +75%sorghum) with mean values of 6.95 and 5.15, respectively. The taste and aftertaste of the biscuit was best with sample E (100%Sorghum) according to the panelist with a mean values of

5.10 and 4.90, respectively. In terms of overall acceptability, sample G (72.5%plantain+22.5%sorghum+5.0%okara) was the most acceptable. Thus, composite flour from which sample G was produced could be used to produce organoleptically acceptable cracker biscuit.

Table 6. Mean Score of Sensory Evaluation of Biscuit from Okara-Fortified Plantain-Sorghum Composite Flour

Sample**	Colour	Texture	Aroma	Taste	After taste	Overall acceptability
A	3.55 ± 0.31^{abc}	3.55 ± 0.28^{a}	1.40 ± 0.11	3.15 ± 0.46	3.45 ± 0.53	3.60 ± 0.21
B	4.00 ± 0.28^{bc}	3.55 ± 0.52^{a}	4.00 ± 0.49	3.80 ± 0.48	4.05 ± 0.39	4.50 ± 0.41
C	4.60 ± 0.23^{c}	6.35 ± 0.62^{cd}	4.95 ± 0.43	3.25 ± 0.24	3.60 ± 0.35	4.90 ± 0.34
D	4.05 ± 0.52^{bc}	6.95 ± 0.40^{d}	5.15 ± 0.52	4.05 ± 0.21	3.85 ± 0.35	5.10 ± 0.39
E	4.45 ± 0.27^{c}	5.45 ± 0.17^{bc}	2.90 ± 0.48	5.10 ± 0.34	4.90 ± 0.59	5.00 ± 0.34
F	3.20 ± 0.34^{ab}	5.10 ± 0.5^{bc}	3.50 ± 0.34	4.00 ± 0.42	3.90 ± 0.37	5.00 ± 0.36
G	3.95 ± 0.38^{bc}	4.90 ± 0.38^{b}	3.30 ± 0.33	4.05 ± 0.03	3.75 ± 0.50	5.20 ± 0.33
H	4.20 ± 0.32^{bc}	5.15 ± 0.48^{bc}	3.20 ± 0.32	3.20 ± 0.19	3.75 ± 0.46	4.70 ± 0.37
I	3.25 ± 0.32^{ab}	5.85 ± 0.43^{bcd}	3.60 ± 0.44	3.60 ± 0.40	4.15 ± 0.44	4.05 ± 0.29
J	2.75 ± 0.31^{a}	4.95 ± 0.51	3.55 ± 0.38	3.55 ± 0.44	3.50 ± 0.48	4.95 ± 0.31

*Values are Mean± SD of triplicate determinations and Mean values with different superscripts in the same column differ significantly at $p < 0.05$..
**Sample key = A [[100P:0S]; B [75P: 25S]; C [50P: 50S] D [25P: 75S]; E [0P: 100S]; F [95P:0S:5K];G[72.25P:22.75S:5K]; H[47.5P:47.5S:5K]; I[22.75P:72.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]

4. Conclusion

From the foregoing, it may be concluded that composite flour made from a blend of plantain and sorghum flours fortified with okara could replace wheat flour for the production of nutritious and organoleptic acceptable biscuit.

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