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

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Abstract
This study evaluates the quality of chin-chin made from Okara fortified plantain-sorghum flour with. The flours of plantain(P), Sorghum (S) and Okara (O) were blended in ratios: P_0 (4 plantain :0 sorghum); P_1S_3(3 plantain:1 sorghum); P_2S_2(2 plantain:2 sorghum); P_3S_1(1 plantain: 3 sorghum); S_0 (4 sorghum: 0 plantain); 5%okara flour was added to 95% of each plantain – sorghum flour blend to give P_0O; P_1S_3O; P_2S P_2O; P_3S_1O; and S_0O respectively. Standard analytical methods were utilized to evaluate the proximate composition, energy and functional properties of the flours, and sensory analysis of the chin-chin. The proximate composition of composite flour and chin-chin showed that sample P_0 possessed the lowest moisture and fat content, and the highest carbohydrate. Sample S_0O has the highest protein content, sample P_0O has highest ash and fibre content, and sample P_2S_2O has highest energy value. There is significant difference ($p < 0.05$) in functional properties: the bulk density, water and oil absorption capacities having the highest value recorded in sample S_0O and the least value in sample P_0. Swelling power and solubility index show no significant difference having sample S_0O with the highest value and sample P_0 having the least value, and wettability shows a significant difference between the samples with P_0O having the highest value and S_0 having the least. This study showed that an acceptable chin-chin produced from composite flour of plantain-sorghum fortified with Okara enhanced the nutritional quality of the product.

Keywords: chinchin, composite, okara, plantain, sensory, sorghum

INTRODUCTION

Chin chin is a tasty, ready to eat convenient snack prepared by either deep frying or baking stiff flour paste to a crunchy golden-brown product. They are low-cost snacks, a much-relished popular street food across Nigeria and most of western Africa (Akubor, 2004). West African population cherishes its consumption (Mepba, Eboh, & Nwaojigwa, 2007).

Okara is *a* non-traditional protein food obtained as a by-product of soymilk and tofu production and is of little or no market value, used mainly as animal feed despite its rich 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). Puechkamut and colleagues worked on the utilization of okara substitute for wheat flour in the production of cookies or bread, and production of useful protein concentrate (Puechkamut & Thiewtua, 2006; Puechkamut, 2007; Puechkamut & Phewnim, 2011; Puechkamut & Panyathitipong, 2012).

Plantain (*Musa paradisiaca,)* is a tropical plant originating from India, and a major staple food crop and source of energy in the humid and sub-humid parts of Africa. It is known in Nigeria as '*Ogedeagbagba*' (Yoruba), '*Ayaba*' (Hausa) and '*Ogadejioke*' (Igbo), and are eaten as boiled, fried or roasted. Also, unripe plantain flour can serve as raw material for preparing different types of baked food. Presence of nutrients such as carbohydrates, minerals, amino acids, fibre, and carotenoids makes plantain an excellent raw material for various food preparation (Ilelaboye and Ogunsina 2018).

Sorghum (Sorghum vulgar and *Sorghum bicolor*) belongs to the grass family-*Poaceae* (Meera, Bhashyam & Ali, 2011) known as millet and guinea corn in West Africa. In the tropical regions of the world, sorghum is a hearty cereal food and feed – crop and consumed mainly by the large human populations in Africa and India, (Sanni, Onitilo, Oyewole, Keiths, & Westby, 2004). Sorghum flour is rich in protein, crude fibre, lipids and ash, and can be used to produce malted foods, beverages, and beer.

Composite flour stands for the mixture of different concentrations of non-wheat flours from cereals, legumes, roots and tubers with or without wheat flour. Composite flour is not only to improve the desired functional properties of the product but also to enhance nutritional composition (Ilelaboye, 2010; Shittu, Raji, & Sanni, 2007). Composite flours have served as a useful raw material in the production of baked goods. (Ilelaboye and Ogunsina 2018)

Over the years, diabetics is advised to consume unripe plantain and wheat flours to regulate blood glucose owing to their high fibre content and low glycemic index. However, the high cost of wheat importation necessitated the need source for functional composite flour from readily available and cheap materials like cereal and legumes (Sorghum and soybean residue (*Okara*)) that possess appropriate nutritional and functional characteristics. Therefore, this study aimed to evaluate the proximate composition, energy value and functional properties of *Okara* fortified plantain-sorghum composite flour, and also determine the nutrient and sensory evaluation of their corresponding chinchin.

MATERIALS AND METHOD

Sample procurement

The fresh plantains, sorghum grains, and soya-bean used for this study were bought from Sayedero market, Ilaro, Ogun State, Nigeria.

Preparation of the Okara fortified Plantain-Sorghum Composite Flours

The plantain flour and sorghum flour were produced according to the procedure described by Ilelaboye and Ogunsina (2018). The okara Flour was prepared using the modified Fukushima's method, as described in Ilelaboye and Ogunsina'(2018). The composite flours were formulated as shown in Table 1

Table1. Percentage composition of plantain, Sorghum and Okara flour

SAMPLE	PLANTAIN	SORGHUM	OKARA
P_0	100	-	-
P_1S_3	75	25	-
P_2S_2	50	50	-
P_3S_1	25	75	-
S_0	-	100	-
P_0O	95	-	5
P_1S_3	72.5	22.5	5
P_1S_3O	47.5	47.5	5
P_3S_1O	22.5	72.5	5
S_0O	-	95	5

Sample Key = P_0 [[100P:0S]; P_1S_3 [75P: 25S]; P_2S_2 [50P: 50S] P_3S_1 [25P: 75S]; S_0 [0P: 100S]; P_0O [95P:0S:5O]; P_1S_3O [71.25P:23.75S:5O]; P_1S_3O [47.5P: 47.5S:5O]; P_3S_1O [23.75P:71.25S:5O]; S_0O [95S:0P:5O] P [Plantain Flour], S[sorghum Flour], O[Okara]

Production of Chinchin from the Composite Flour

All the chin chin ingredients (including the composite flours) were mixed together to form a dough, which was kneaded on a flat floured surface and rolled out to approximately 2 cm thickness and then cut into squares of 2 cm by 2 cm in size. A deep fryer of MC 1800 model was filled with vegetable oil, heated to a temperature of 180 ºC, and this was then filled with the dough cubes, and allowed to fry for 8 mins until golden brown. The fried chin chin was removed and excess oil drained off, cooled before serving (Akubor, 2004).

Table 2. Ingredients composition for chinchin production

Ingredient	Quantity
Composite flour	100 g
Sugar	5 g
Fat	3 g
Egg	10 g
Baking Powder	10 g
Water	70 ml
Vegetable oil	1Litre

Chemical analysis

The proximate composition of the composite flours analyzed using the procedure of the Association of Official Analytical Chemist (AOAC, 2006), and the energy value calculated using Atwater factors (Ilelaboye, 2019). Appropriate standard methods were utilized to determine the following functional properties of the flours: Water and oil absorption capacities; swelling power and solubility index by Julianti, Rusmarilin, & Yusraini (2015) procedures, bulk density by Oyeyinka et al. (2014) technique. Wettability of the flours was determined as described by Onwuka, 2005.

Sensory evaluation

Sensory evaluation of the chin chin samples prepared from the Okara fortified plantain-sorghum blends was performed using the 9 points Hedonic scale quality analysis where 1 (one) corresponds to like extremely, and 9 (nine) equals to dislike extremely. (Iwe, 2002). Twenty (20) trained panelists drawn from students and staff of the Federal Polytechnic, Ilaro, Ogun State, Nigeria, evaluated the chin chin samples for colour, aroma, taste, aftertaste and overall acceptability using the scale.

Statistical analysis

All analyses carried out in triplicate, with statistical significance established using one-way analysis of variance (ANOVA), and data reported as the mean ± standard deviation. Mean comparison and separation done using Duncan Multiple range (DMR) test at P≤ 0.05, described by the SPSS 16.0 statistical package. (SPSS, 16, 2008).

RESULTS AND DISCUSSION

Proximate composition

The moisture content of the composite flour, as shown in Table 3, increases significantly ($p < 0.05$) from each other, ranging from 5.72 to 7.92% as the percentage of sorghum flour substitution increases, and addition of okara powder. There is better shelf stability of the flour with low moisture content without spoilage through chemical changes or by micro-organism during storage (Shahzadi, Butt, Rehman, & Sharif, 2005; Akomolafe & Aborisade, 2007). The moisture content of chin chin produced from the composite flour ranged from 7.00 to 8.9% (Table 4) and is higher than that of chin chin made from wheat (4.9%), and this could be as a result of high moisture content of Sorghum and Okara in the composite flour. (Adegunwa, Ganiu, Bakare & Adebowale, 2014),

The composite flours ash content varied significantly ($P < 0.05$), ranging from **S_0** (1.72 %) to **P_0O** (**2.62**%).

The ash content of **P_0O** is higher than that of the wheat flour recorded to be 2.0% (Nneka, & Charles, 2016). Ash contents indicate a rough estimation of the minerals content of the product; hence, **P_0O** has the highest mineral content. The ash content of chinchin produced by the composite flour ranged from 3.0% to 3.5% and are less than wheat chinchin ash content (4.97%.) recorded by Adegunwa et al. 2004. The presence of okara in the composite flours has no significant impact on the ash content of chin chin produced.

Table 3: The proximate composition (%) and energy (kcal/100 g) values of the okara fortified plantain-sorghum composite flour

Samples	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate	Energy
P_0	$5.72^{a}\pm.22$	$2.52^{e}\pm.06$	$2.12^{a}\pm.08$	$2.92^{a}\pm.06$	$4.02^{g}\pm.16$	$84.02^{i}\pm.02$	$363.22^{ab}\pm09$
P_1S_3	$6.22^{c}\pm.09$	$2.22^{d}\pm.08$	$2.32^{b}\pm.05$	$3.09^{a}\pm.28$	$3.52^{e}\pm.15$	$83.62^{h}\pm.05$	$365.52^{ab}\pm.07$
P_2S_2	$6.62^{d}\pm.06$	$2.02^{c}\pm.05$	$2.42^{c}\pm.06$	$4.12^{c}\pm.05$	$3.22^{c}\pm.11$	$82.92^{g}\pm.06$	$363.72^{b}\pm.04$
P_3S_1	$7.02^{e}\pm.08$	$1.82^{ab}\pm.02$	$2.42^{c}\pm.14$	$4.62^{de}\pm.08$	$3.02^{b}\pm.02$	$82.42^{f}\pm.09$	$366.42^{a}\pm.20$
S_0	$7.92^{g}\pm.03$	$1.72^{a}\pm.15$	$2.52^{cd}\pm.12$	$5.82^{f}\pm.09$	$2.72^{a}\pm.07$	$80.62^{c}\pm.05$	$364.92^{b}\pm.09$
P_0O	$5.72^{a}\pm.05$	$2.62^{e}\pm.07$	$2.67^{e}\pm.09$	$3.42^{b}\pm.10$	$4.12^{g}\pm.03$	$82.84^{g}\pm.03$	$365.27^{ab}\pm.04$
P_1S_3	$6.02^{b}\pm.10$	$2.22^{d}\pm.11$	$2.84^{ef}\pm.07$	$4.44^{cd}\pm.11$	$3.82^{f}\pm.04$	$81.83^{e}\pm.04$	$366.40^{ab}\pm.08$
P_1S_3O	$6.62^{d}\pm.12$	$2.02^{c}\pm.04$	$2.93^{fg}\pm.02$	$4.82^{e}\pm.13$	$3.62^{e}\pm.09$	$81.28^{d}\pm.012$	$367.37^{ab}\pm.07$
P_3S_1O	$7.02^{e}\pm.04$	$1.92^{bc}\pm.13$	$3.03^{gh}\pm.06$	$5.92^{fg}\pm.15$	$3.42^{d}\pm.05$	$80.42^{b}\pm.11$	$369.11^{b}\pm.06$
S_0O	$7.62^{f}\pm.07$	$1.82^{ab}\pm.03$	$3.11^{h}\pm.08$	$6.22^{g}\pm.05$	$3.02^{b}\pm.08$	$79.40^{a}\pm.15$	$67.35^{ab}\pm.05$

*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 = P_0 [[100P:0S]; P_1S_3 [75P: 25S]; P_2S_2 [50P: 50S] P_3S_1 [25P: 75S]; S_0 [0P: 100S]; P_0O [95P:0S:5O]; P_1S_3O [71.25P:23.75S:5O]; P_1S_3O [47.5P: 47.5S:5O]; P_3S_1O [23.75P:71.25S:5O]; S_0O [95S:0P:5O] P [Plantain Flour], S[sorghum Flour], O[Okara]

Table4: Proximate composition of chin-chin

Sample	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate	Energy
P_0	$7.00^{a}\pm.12$	$3.50^{c}\pm.09$	$4.00^{a}\pm.12$	$3.80^{a}\pm.05$	$3.90^{e}\pm.15$	$74.00^{f}\pm.14$	$347.20^{i}\pm.08$
P_1S_3	$7.30^{b}\pm.17$	$3.30^{b}\pm.08$	$4.10^{ab}\pm.06$	$4.43^{b}\pm.09$	$3.70^{d}\pm.06$	$71.53^{e}\pm.67$	$344.10^{g}\pm.06$
P_2S_2	$7.80^{c}\pm.06$	$3.20^{ab}\pm.06$	$4.20^{bc}\pm.07$	$5.50^{d}\pm.06$	$3.50^{c}\pm.09$	$70.83^{d}\pm.60$	$339.80^{e}\pm.06$
P_3S_1	$8.40^{e}\pm.09$	$3.20^{ab}\pm.05$	$4.30^{c}\pm.17$	$6.57^{e}\pm.08$	$3.20^{b}\pm.06$	$66.17^{b}\pm.73$	$334.77^{c}\pm.38$
S_0	$8.90^{f}\pm.10$	$3.00^{a}\pm.12$	$4.50^{d}\pm.07$	$7.70^{g}\pm.09$	$3.00^{a}\pm.12$	$65.50^{b}\pm.29$	$331.70^{a}\pm.06$
P_0O	$7.20^{ab}\pm.05$	$3.50^{c}\pm.16$	$4.70^{e}\pm.06$	$4.30^{b}\pm.06$	$4.20^{f}\pm.08$	$71.73^{e}\pm.09$	$346.30^{h}\pm.06$
P_1S_3	$7.40^{b}\pm.12$	$3.40^{bc}\pm.06$	$4.80^{ef}\pm.09$	$5.17^{c}\pm.14$	$3.90^{e}\pm.06$	$69.96^{d}\pm.03$	$343.86^{j}\pm.06$
P_1S_3O	$7.70^{c}\pm.17$	$3.27^{b}\pm.09$	$4.90^{fg}\pm.18$	$6.53^{e}\pm.09$	$3.80^{d}\pm.09$	$67.60^{c}\pm.06$	$340.20^{c}\pm.06$
P_3S_1O	$8.10^{d}\pm.06$	$3.20^{ab}\pm.17$	$5.00^{g}\pm.06$	$5.00^{g}\pm.06$	$3.50^{c}\pm.15$	$65.61^{b}\pm.06$	$336.59^{d}\pm.09$
S_0O	$8.50^{e}\pm.14$	$3.20^{ab}\pm.06$	$5.20^{h}\pm.04$	$8.00^{h}\pm.06$	$3.27^{b}\pm.09$	$63.49^{a}\pm.06$	$333.16^{b}\pm.06$

*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 = P_0 [[100P:0S]; P_1S_3 [75P: 25S]; P_2S_2 [50P: 50S] P_3S_1 [25P: 75S]; S_0 [0P: 100S]; P_0O [95P:0S:5O]; P_1S_3O [71.25P:23.75S:5O]; P_1S_3O [47.5P: 47.5S:5O]; P_3S_1O [23.75P:71.25S:5O]; S_0O [95S:0P:5O] P [Plantain Flour], S[sorghum Flour], O[Okara]

Increasing the level of sorghum, and inclusion of okara in the composite flour blends resulted in significant ($p< 0.05$) increase of their fat content. Fasasi (2009) reported that product with low-fat content have better shelf life because chances of rancidity are reduced, and also impact a calorie on the product. The fat content of chinchin produced from the composite flours exhibited the same trend as their corresponding flours, and smaller than the fat content (8.13%) of chinchin produced from wheat by Adegunwa et al. (2014).

The protein content of the composite flour blends varied significantly ($p< 0.05$) ranging from P_0

(2.92%) to S_0O (6.22%) and is lower than that of wheat which was reported by Nneka et al. (2016) as 10.12%. The fortification of the composite flour with okara has a positive impact on the flour. The protein content of the chin chin produced from the blended flour ranged from (3.8%) to (8.0%) for sample P_0 and S_0O, respectively This study revealed that there was an increase in protein content of chinchin than the protein content of the composite flour blends, which may be due to the ingredient used in the production. The protein content of chinchin produced in this study is lower than the protein content (19.99 %) of chinchin made from wheat (Adegunwa et al., 2014).

There is a significant ($P< 0.05$) decline in the fibre content of the composite flours as the level of sorghum increases, but the addition of okara raised the per cent fibre of plantain – sorghum blends. The highest per cent fibre in P_0O is caused the high fibre content in plantain and okara (Kiin-Kabari & Giami, 2015). Chinchin fibre content followed the same trend as the composite flour ranging from S_0 (3.0%) to P_0O (4.2%), and lower than wheat chinchin fibre content (5.23%) (Adegunwa et al., 2014)

The composite flours' carbohydrate content varied significantly ($p< 0.05$), and higher than the carbohydrate content of wheat (76.30%) recorded by Nneka et al., (2016). Addition of sorghum and okara to the flours caused a reduction in the carbohydrate content of the corresponding chinchin. There is a significant ($P< 0.05$) variation in energy value of the okara fortified plantain – sorghum flour blends, with P_0 possessing the lowest value. The fortification of the composite flour with okara has a positive impact on the flour. The energy content of chinchin produced from the composite flour ranged from 333.16 kcal/100 g to 347.2 kcal/100 g.

Functional properties

The particle size of the flour determines its porosity hence the bulk density of the flour. The flour bulk density influences the choice and price its packaging material, and controls its application in wet processing of raw material in the food industry (Iwe & Onalope, 2001; Adebowale, Sanni & Onitilo, 2008; Ajanaku, Ajanaku, Edobor- Osoh & Nwinyi, 2012). As presented in Table 3, significant ($p<0.05$) variation exist in the bulk density (B.D.) of the flours ranging from P_0 (0.56±0.03 g/ml) to S_0O (0.85±0.03 g/ml). Increasing the level of sorghum flour, and the addition of okara caused a rise in the bulk density of the flours. The bulk density of P_0agrees with the results of other researchers. (Abioye, Ade-Omowaye, Babarinde & Adesigbin, 2011; Kiin-Kabari, Eke-Ejiofor & Giami, 2015).

As shown in Table 5, the water absorption capacity (WAC) of the flour blends rose as the amount of Sorghum in the flours increased. Also, the inclusion of Okara improved the flours WAC due to its high protein content and confirmed the other researchers' reports that the WAC of flours is regulated by their protein content (Kiin-Kabari et al., 2015; Adebowale et al., 2008; Butt & Batool, 2010). Flours with high WAC is suitable for bakery products that involve hydration to enhance dough handling characteristics. The oil absorption capacity (OAC) of the blends followed the same pattern, and the flours' protein content has a positive influence on their OAC (Jilngarmkusol, Hongsuwankul, & Tananuwong, 2008). Therefore, sample P_0O with high OAC will be suitable to produce bakery products as it will retain flavour and increase the mouthfeel of the product (Adegunwa et al., 2017).

The swelling power ranged from 4.93g/g to 10.21g/g among all the samples. The quantity of protein in the flour regulates its swelling power because the affinity of starch granules to water is improved by the presence of protein (Woolfe, 1992; Aprianita, Purwandari, Watson, & Vasiljevic, 2009), hence, S_0O with the highest protein value has the highest swelling power. Tester and Morrison (1990), and Moorthy and Ramanujam (1986) reported that the degree of associative forces within the granules and the ratio of amylase to amylopectin controls the swelling power of flour. The swelling power gotten in this study for 100% plantain was 4.93 g/g, and is lower than the values reported by Abioye, Ade-Omowaye, Babarinde and Adesigbin, (2011) and Abioye et al., (2011) for 100% plantain flour (8.22g/g) which may be as a result of variety difference 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 ($p<0.05$) 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.

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

Functional Properties	B.D. (g/ml)	WAC (%)	OAC (%)	S.P. (g/g)	S.I. (%)	W.A. (Secs)
P_0	0.56 ± 0.03^a	2.30 ± 0.00^b	2.20 ± 0.00^b	4.93 ± 0.03^b	36.60 ± 0.60^b	99.00 ± 0.00^g
P_1S_3	0.60 ± 0.03^c	2.84 ± 0.03^a	2.40 ± 0.00^b	5.70 ± 0.00^b	36.88 ± 0.00^b	26.67 ± 0.67^b
P_2S_2	0.63 ± 0.03^{ab}	3.35 ± 0.00^b	2.60 ± 0.00^b	6.60 ± 0.00^b	37.00 ± 0.00^b	25.53 ± 0.67^b
P_3S_1	0.68 ± 0.03^d	3.90 ± 0.00^b	2.78 ± 0.00^b	7.40 ± 0.00^b	37.22 ± 0.00^b	24.40 ± 0.00^b
S_0	0.73 ± 0.03^{cd}	4.47 ± 0.03^f	3.00 ± 0.00^b	8.20 ± 0.04	37.43 ± 1.23^b	24.33 ± 0.00^b
P_0O	0.71 ± 0.03^a	5.10 ± 0.00^b	3.49 ± 0.00^b	10.00 ± 0.00^b	49.70 ± 0.00^b	105.33 ± 0.33^h
P_1S_3	0.74 ± 0.03^d	5.50 ± 0.00^b	3.65 ± 0.00^b	7.83 ± 0.00^b	49.93 ± 0.00^b	80.50 ± 0.00^b
P_1S_3O	0.77 ± 0.03^f	6.00 ± 0.00^b	3.81 ± 0.00^b	8.50 ± 0.00^b	50.00 ± 0.00^b	75.60 ± 0.00^b
P_3S_1O	0.83 ± 0.03^{ac}	6.60 ± 0.00^b	4.00 ± 0.00^b	9.53 ± 0.00^b	50.35 ± 0.00^b	60.50 ± 0.00^b
S_0O	0.85 ± 0.03^e	7.00 ± 0.00^b	4.30 ± 0.00^b	10.21 ± 0.00^b	50.53 ± 0.00^b	56.82 ± 0.00^b

*Values are Mean ± S.D. of triplicate determinations and Mean values with different superscripts in the same column differ significantly at p .05.**Sample Key = P_0 [[100P:0S]; P_1S_3 [75P: 25S]; P_2S_2 [50P: 50S] P_3S_1 [25P: 75S]; S_0 [0P: 100S]; P_0O [95P:0S:5O]; P_1S_3O [71.25P:23.75S:5O]; P_1S_3O [47.5P: 47.5S:5O]; P_3S_1O [23.75P:71.25S:5O]; S_0O [95S:0P:5O] P [Plantain Flour], S[sorghum Flour], O[Okara] BD[bulk density], WAC[water absorption capacity], OAC [oil absorption capacity], SP [swelling power], SI[solubility index], WA [wettability].

Wettability is the time taken for samples to absorb water, and the result varied significantly ranging from S_0 (23.33 sec) to P_0O (115.33 sec). The wet ability of the composite flours reduced as the level of Sorghum increased in the blends; however, the addition of okara to the composite flours extend the wetting time of the flours. The fortified composite flours took a longer period to sink in water because okara might have changed the physical compositions of the flour blends and made it less susceptible to imbibe water (Oluwamukomi, Adeyemi, & Oluwalana, 2005).

Table 6: Sensory evaluation of chin-chin

SAMPLE	COLOUR	TEXTURE	AROMA	TASTE	AFTER TASTE	OVERALL ACCEPTABILITY
P_0	$4.80^{ab}\pm0.35$	$5.55^{a}\pm0.34$	$6.15^{bcd}\pm0.15$	$6.20^{a}\pm0.30$	$5.65^{bc}\pm0.27$	$5.80^{a}\pm0.25$
P_1S_3	$4.60^{a}\pm0.31$	$5.58^{bc}\pm0.30$	$5.45^{abcd}\pm0.18$	$6.25^{a}\pm0.22$	$5.79^{d}\pm0.15$	$6.50^{ab}\pm0.21$
P_2S_2	$5.30^{ab}\pm0.39$	$5.60^{a}\pm0.30$	$5.20^{cd}\pm0.32$	$6.30^{a}\pm0.22$	$6.00^{cd}\pm0.16$	$6.30^{ab}\pm0.33$
P_3S_1	$5.10^{ab}\pm0.30$	$5.69^{abc}\pm0.39$	$5.16^{d}\pm0.28$	$6.45^{a}\pm0.34$	$6.30^{bcd}\pm0.25$	$6.50^{ab}\pm0.28$
S_0	$5.05^{ab}\pm0.26$	$5.80^{a}\pm0.31$	$5.00^{ab}\pm0.22$	$6.55^{a}\pm0.27$	$6.60^{d}\pm0.20$	$6.50^{ab}\pm0.27$
P_0O	$4.50^{a}\pm0.30$	$5.70^{ab}\pm0.18$	$6.20^{abcd}\pm0.30$	$6.27^{a}\pm0.22$	$5.00^{a}\pm0.31$	$5.90^{a}\pm0.25$
P_1S_3	$5.25^{ab}\pm0.38$	$5.75^{a}\pm0.26$	$5.59^{abc}\pm0.26$	$6.32^{a}\pm0.19$	$5.30^{b}\pm0.23$	$6.80^{b}\pm0.19$
P_1S_3O	$5.20^{ab}\pm0.40$	$6.30^{abc}\pm0.17$	$5.45^{a}\pm0.39$	$6.45^{a}\pm0.14$	$5.55^{d}\pm0.21$	$6.55^{ab}\pm0.31$
P_3S_1O	$5.55^{ab}\pm0.26$	$6.70^{bc}\pm0.21$	$5.32^{abcd}\pm0.33$	$6.50^{a}\pm0.37$	$6.15^{bcd}\pm0.28$	$6.55^{ab}\pm0.29$
S_0O	$5.85^{ab}\pm0.26$	$6.95^{c}\pm0.18$	$5.10^{abcd}\pm0.31$	$6.55^{a}\pm0.32$	$6.90^{bcd}\pm0.30$	$6.95^{b}\pm0.23$
K	$7.33^{ab}\pm0.05$	$7.07^{c}\pm0.03$	$7.40^{a}\pm0.29$	$7.73^{b}\pm0.10$	$7.00^{d}\pm0.17$	$7.67^{b}\pm0.29$

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

**Sample Key = P_0 [[100P:0S]; P_1S_3 [75P: 25S]; P_2S_2 [50P: 50S] P_3S_1 [25P: 75S]; S_0 [0P: 100S]; P_0O [95P:0S:5O]; P_1S_3O [71.25P:23.75S:5O]; P_1S_3O [47.5P: 47.5S:5O]; P_3S_1O [23.75P:71.25S:5O]; S_0O [95S:0P:5O] P [Plantain Flour], S[sorghum Flour], O[Okara] K[wheat flour}

The organoleptic test was carried out on all the chin chin prepared from the experimental flours and chinchin made from wheat flour to enable comparison. The sensory evaluation result of the chinchin made from okara fortified plantain-sorghum flour blend and wheat chinchin, as depicted in Table 6 shown a diverse significant difference in all the parameters assessed. Out of all the samples rated by the panellist in terms of colour, texture, taste, aftertaste and overall acceptability, sample S_0O scored the highest points with mean values of 5.85, 6.95, 6.55, 6.90 and 6.65, respectively, and statistically next to wheat chin chin with values 7.33, 7.07, 7.73,7.00, and 7.67, respectively. The most acceptable fortified flour's chinchin in terms of aroma is sample P_0O (95% plantain +5%okara) with a mean value of 6.20 this could be due to the high content of plantain flour in the composition. Sample S_0O (95% sorghum +5% okara) can replace wheat flour in the preparation of chinchin to be organoleptically acceptable.

CONCLUSION

The okara enriched plantain-sorghum flours and their corresponding chinchin in this study are nutritionally better in terms of protein, crude fibre and fat compared to wheat flour. The fortification of the sorghum with 5% okara shows a notable increase in protein content. As revealed in the results above, highly nutritious food/flour can be produced from plantain-sorghum blend fortified with okara. The composite flours could serve as the best substitute for wheat flour in the production of baked products that can be used to fight protein malnutrition in developing countries. The study revealed that inclusion of okara flour in plantain - sorghum blend increased the protein level, hence, enhanced the functional properties of the flours which are desirable characteristics for the manufacture of starchy meals, and could serve as an advantage in the both domestic and industrial use of these crops.

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