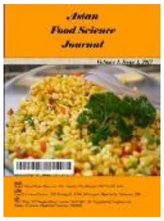

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Proximate Composition, Functional Properties and Sensory Evaluation of Stiff Dough (Amala) Prepared from *Okara* Fortified Plantain-Sorghum Flours

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Authors' contributions

This work was carried out in collaboration between both authors. Author NOI designed the study, reviewed the literature searches and managed the experimental process and performed statistical analyses of the experiment. Author TIO performed the experimental process and analysis, wrote the first draft of manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The study investigated the proximate composition and some functional properties of *okara* (soymilk residue) fortified plantain-sorghum composite flours and assessed the consumer's acceptability of stiff dough (*Amala*) prepared from the flours. Composite flours produced from plantain [P] (*Musa paradisiacal*) flour and sorghum [S] (*Sorghum bicolor*) flour in the ratio: 100:0; 75: 25; 50: 50;; 75 : 25 100 :0 a portion of each composite flour was fortified with 5% *okara* [soymilk residue] flour, making a total of 10 samples [A – J]. The proximate composition shows that moisture content ranged from 6.21±1.17% to 11.2±2.31%, ash (0.32±0.02% to 3.55 ±0.68%), crude fat (1.77±0.03% to 3.56±0.37%), crude protein (2.09±0.11% to 5.30±0.39%), crude fibre (9.38±1.44%, to 12.20±2.30%), carbohydrate (64.33±5.32% to 75.65±4.53%), and energy (305.16±14.87 kcal to 333.36±21.11 kcal). *Okara* has a positive impact on the proximate composition of the flour. The functional properties shows bulk density ranged from 0.45±0.02 g/mL to 0.57±0.01 g/mL, water absorption capacity (164.65±19.73% to 219.40±11.41%), oil absorption capacity (96.45±3.46% to 148.65±14.35%), swelling power (9.97±2.02 g/g to 5.87±1.02 g/g) solubility index (36.60±0.60% to 50.53±0.00%), and wettability (27.33±2.13 Sec to 135.33±12.33 Sec). The sensory evaluation of the

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stiff dough revealed that sample G is the most acceptable, and sample F the least acceptable. This study revealed that *Okara* fortified plantain-sorghum flour could serve as raw materials in food industries, and as staple foods in various households.

Keywords: Proximate composition; functional properties; sensory evaluation; composite flour; Okara.

1. INTRODUCTION

Foods that possess both nutritional properties and specific health benefits are called functional foods because their consumption can prevent and/or manage chronic diseases. Dietary management of diabetes recommends intake of three regular balanced diets of a regulated content of carbohydrate, protein, fat, to enhance insulin action and prevent a sudden upsurge in blood glucose level. One of the major difficulties diabetic patients encounter is the insufficient availability of carbohydrate-rich food that is rich in dietary fiber. Over the years unripe plantain with wheat flour was recommended for regulating blood glucose due to their high fiber and low glycemic index, but the cost of importation associated with wheat, called for the need to produce composite flour from other readily available and cheaper crops (plantain, sorghum, and *okara*) with good nutritional value of proteins, carbohydrates, fibers, fat and ash contents.

Composite flour is the aggregate blends of different flours from other crops such as cereals, legumes, roots and tubers with or without wheat flour. They are produced to upgrade the food qualities and boosted anticipated functional properties of the finished product [1,2]. Several bakery products have been extensively and successfully produced from composite flours.

Plantain, *Musa paradisiaca* of the family *Musaceae* and locally called '*Ogede agbagba*' in Yoruba, '*Ayaba'* in Hausa and '*Ogadejioke'* in Igbo, is a major staple food crop and source of energy for millions of people in the tropical humid regions of Africa. Nigeria the largest producer of plantain in West Africa was reported to have an annual yield of 2.4 million metric tons [3].

Plantain is consumed as boiled, fried or roasted, and when processed into flour, it is used traditionally for making a stiff dough (*Amala*) which is usually consumed by diabetics to reduce postprandial glucose level because of its low glycemic index [4,5]. Several kinds of research have been done on the processing, utilization, evaluation of nutritional quality and starch characteristic of unripe plantains flour [6,7,8,9].

Sorghum is an important food and feed crop in the semi-arid regions of the world. In West Africa, Sorghum is known as great millet and guinea corn and serve as a staple diet for large populations, where nearly all the produce is used directly as human food. Sorghum grain is a good source of starch, protein, vitamin B-complex, and it is processed into various food products around the world and several authors have researched the potential food and industrial applications of sorghum such as baked bread, porridge, tortillas, malted foods, alcoholic, and non-alcoholic beverages, and so on [10,11]. Sorghum flour is beneficial for patients with diabetes, hypertension and heart diseases because it has resistant starch [12,13].

Okara (Soymilk residue) is a by-product of soymilk and tofu production and can be grouped as non-traditional soy protein food. This by-product had little or no market value and was used mainly as animal feed despite its rich nutrient content. However, *okara* contains about 27% protein (dry weight basis), 10% oil, 42% insoluble fiber and 12% soluble fiber [14]. Extensive researches have been done by Puechkamut and colleagues [15, 16, 17, 18].on the utilization of *okara*, for example, substituting if for wheat flour to produce cookies or bread, and extracting valuable protein from *okara*. Soybean fibre exhibit multiple physiological benefits, in regulating glucose metabolism and nutrients absorption [19].

Over the years unripe plantain and wheat flour were recommended for regulating blood glucose due to their high fibre content and low glycemic index. The cost of importation of wheat, and the need for production of functional composite flour using other readily available and inexpensive materials such as cereal and legumes, sorghum and soybean residue *(okara)*, with a good proximate is necessary. Therefore this study aims to produce functional composite flour from plantain, sorghum and *okara*, evaluate the proximate composition, functional properties of resulting flours, and the sensory attributes of stiff dough (*Amala*) prepared from the flours.

2. MATERIALS AND METHODS

2.1 Sample Procurement

The fresh plantains, Sorghum grains, and Soya bean used for this study were bought from Sayedero market, Ilaro in Ogun State, Nigeria.

2.2 Preparation of Plantain Flour

The modified method of Ibeanu et al. [20] was used in the production of plantain Flour. A 20 kg of unripe plantain fingers were washed and sun-dried for 30 min. The fruits were then hand peeled, sliced and stored in water to avoid browning before drying. The sliced pulp was dried in a hot air oven for 6 hr at a temperature of 80°C immediately. The resultant dried pulp was milled with a hammer mill (Bentall Superb, Model 200 L 09) and sieved through a 75 µm mesh sieve and kept in airtight plastic containers at room temperature for further use.

2.3 Preparation of Sorghum Flour

Sorghum grains (5 kg) were screened of foreign bodies, washed with clean water and dried in an open air for 4 hr. After which the dried grains milled with hammer mills (Bentall Superb Model 200 L 09) through a 75 µm mesh sieve and stored in airproofed plastic containers at room temperature for further use.

2.4 Preparation of Soybean Residue *(Okara)* Flour

The method of Fukushima [21] was used to prepare the soybean residue, the foreign materials and spoilt grains in the soybean were removed by floatation water. The beans were dehulled after blanching in hot water (100°C) for 25 min. The dehulled cotyledons were washed twice with hot (100°C) water, were milled with hammer mills (Bentall Superb Model 200 L 09) using 5 liters of water to 1 kg of grains. The residue called *okara* was obtained by filtering the slurry through a muslin cloth and dried in a hot-air oven at a temperature of 70°C, milled into fine powder passing through a 75 µm mesh sieve and stored in airtight plastic containers for further use.

2.5 Preparation of Composite Flours

The plantain and sorghum flours were mixed together according to proportion in Table 1, and 5% *okara* [22] was added to each blend and homogenized using a Cross-Flow blender for 30 min. The composite flours thus obtained were then stored separately in tightly covered plastic containers for later use.

Table 1. Proportion of plantain, sorghum, and *Okara* in the composite flour (%)

Sample	Plantain %	Sorghum %	Okara%
A	100	0	0
B	75	25	0
C	50	50	0
D	25	75	0
E	0	100	0
F	95	0	5
G	71.25	23.75	5
H	47.5	47.5	5
I	23.75	71.25	5
J	0	95	5

2.6 Preparation of Amala

Amala was prepared by pouring 50 g of the composite flour into 200 mL boiling water with continuous stirring until a smooth, thick mixture was formed. The mixture was covered to simmer for about 5 min. It was further stirred, packed and wrapped with thin labeled polythene wraps.

2.7 Chemical Analysis

The proximate composition of the composite flours were analysed according to the method described by AOAC, [23], while Atwater factors [24] was used to calculate the energy value of the samples The following functional properties of the flours were studied using appropriate standard methods:

2.7.1 Determination of swelling power and solubility index

Swelling power and solubility index were determined using the modified method described by Takashi and Sieb [25]. One (1) gram of the sample was put into 50 mL centrifuge tube. 50 mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 80°C for 15 min. During heating, the slurry was stirred gently to prevent clumping of the flour. On completion of 15 min, the tube containing the paste was centrifuged at 3000 rpm for 10 mins. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of the sediments gel was, therefore, determined to get the dry matter content of the gel.

$$Swelling\ power = \frac{weight\ of\ wet\ mass\ sediment}{weight\ of dry\ matter\ in\ the\ gel}$$

$$Solubility\ index\ (\%) = weight\ of\ dried\ solid\ after\ drying \times 100$$

2.7.2 Determination of bulk density

Bulk density was determined using the method as described by Akpapunam and Markakis [26]. Ten (10) grams of sample was weighed into 50 mL graduated measuring cylinder and the bottom of the cylinder was tapped repeatedly on a firm pad on a laboratory bench until a constant volume was observed. Theolume was recorded and bulk densities was calculated as the ratio of the sample weight to the volume occupied by the sample.

$$Bulk\ density(g/cm^3) = \frac{Weight\ of\ sample\ (g)}{volume\ occupied\ (cm^3)}$$

2.7.3 Determination of water and oil absorption capacities

Water and oil absorption capacities were determined according to the method described by Okezie and Bello [27]. One (1) gram of each sample was mixed with 20 mL distilled water (for water absorption capacity) and 20 mL of oil (for oil absorption capacity) in a flask shaker and centrifuged at 2,000 rpm for 1 hr. Water/oil absorbed by samples was calculated as the difference between the initial and final volumes of water/oil.

$WAC = V_O - V_1$

Where,

WAC = Water absorption capacity
V_O = Initial volume of water (20ml)
V_1 = Volume of water (supernatant)
$OAC = V_O - V_1$

Where,

OAC = Oil absorption capacity
V_O = Initial volume of oil (20ml)
V_1 = Volume of oil (supernatant)

2.7.4 Determine of wettability

The method of Onwuka [28] was used.to determine wettability of the flours. 1 cm, One (1) gram of sample was weighed into a 25 mL graduated cylinder. A finger was placed over the open end of the cylinder which was inverted and clamped at a height of 1 0cm from the surface of a 600 mL beaker containing 500 mL of distilled water. The finger was removed and the flour was allowed to be damped. The wettability is the time required for the sample to become completely wet.

2.8 Sensory Evaluation

Sensory evaluation of the *amala* samples prepared from the composite flours was performed 4 hr after production using the 9 points Hedonic scale quality analysis [29]. The evaluation was done using 20 untrained panelists drawn from students and staff of the Federal Polytechnic, Ilaro Ogun State Nigeria.. The attributes evaluated in the coded amala samples were color, aroma, taste, texture, aftertaste, and general acceptability.

2.9 Statistical Analysis

All analyses were carried out in triplicate. Statistical significance was established using one-way analysis of variance (ANOVA), and data were reported as the mean ± standard deviation. Mean comparison and separation was done using Duncan Multiple range (DMR) test at $p \leq 0.05$. Statistical analysis was carried out using the SPSS 16.0 statistical package [30].

3. RESULT AND DISCUSSION

3.1 Proximate Compositions of the Flours

The proximate composition of the composite flours are given in Table 2, the moisture content of the composite flours differs significantly ($p < 0.05$), ranging from sample F. (11.2±2.31%) to sample E. (6.21±1.17%). The result shows that *okara* increased the percent moisture in the plantain - sorghum composite flours due to the existence of a continue water film on the surface of *okara* flour [22] and the moisture in sorghum flour is lower than that of plantain flour. The percent moisture of all composite flours reported in this study is below 15% which is the recommended maximum limit for Flours [31]. This shows that the composite flours will have longer shelf-life [31].

Sample A had the lowest ash content [0.32±0.02 %] while the highest (3.55 ±0.68%) was found in Sample J (100%sorghum supplemented with 5% *okara*). Sample B ash content of (0.62±0.01%) is comparable to the result obtained by other

Table 2. Effect of *okara* addition on the proximate composition (%) and energy (Kcal/100g) values of the composite flour

Sample**	Moisture	Ash	Protein	Fibre	Fat	Carb	Energy
A	9.88±1.31^{i*}	0.32±0.02^{a}	3.71±0.27^{g}	9.38±1.443^{a}	1.77±0.03^{a}	75.65±1.53^{j}	333.36±21.11^{g}
B	6.75±1.01^{c}	0.62±0.01^{b}	3.47±0.31^{f}	10.62±1.81^{ab}	2.43±0.05^{c}	74.27±6.14^{i}	332.83±17. 13^{f}
C	8.56±1.38^{g}	1.75±0.05^{d}	3.04±0.33^{c}	10.82±1.56^{bc}	2.90±0.06^{d}	73.24±5.88^{h}	331.22±18.51^{e}
D	8.15±0.81^{f}	1.95±0.31^{e}	2.66±0.21^{b}	10.07±2.31^{b}	3.18±0.81^{e}	72.36±7.07^{f}	328.70±20.31^{cd}
E	6.21±1.17^{a}	3.37±0.83^{h}	2.09±0.11^{a}	12.20±2.30^{f}	3.56±0.37^{h}	69.20±5.06^{c}	317.42±16.33^{bc}
F	11.20±2.31^{j}	0.62±0.03^{b}	5.30±0.39^{i}	10.24±1.87^{ab}	2.23±0.83^{b}	72.52±4.35^{g}	331.35±16.64 ^{e}
G	7.94±1.11^{d}	0.74±0.07^{c}	4.88±0.73^{h}	11.82±2.35^{ef}	3.26±0.43^{f}	70.90±5.37^{e}	332.46±19.03^{f}
H	8.03±1.34^{e}	2.11±0.37^{f}	3.42^{f}±0.21	11.89±2.03^{ef}	3.68±0.73^{i}	69.81±6.01^{d}	326.04±18.44 ^{c}
I	8.89±1.69^{h}	2.71±0.55^{g}	3.23±0.53^{e}	11.38±1.73^{cd}	3.83±0.65^{j}	67.14±5.71^{b}	315.95±19.31^{b}
J	6.58±0.56^{b}	3.55±0.68^{i}	3.14±0.15^{d}	13.41±2.42^{g}	3.92±0.33^{g}	64.33±5.32^{a}	305.16±14.87^{a}

Values are Mean± SD** of triplicate determinations, and Mean values in the same column with different superscripts are significantly different 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[71.25P:23.75S:5K]; [H47.5P: 47.5S:5K]; I[23.75P: 71.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]*

workers analysis on ash content [0.6 to 1.10%] of unripe plantain [32,33]. Since the ash content of foodstuff represents the number of mineral elements available in it, Sample J having high ash content will possess high mineral content.

The protein content shows that protein of the composite flours decreased as the level of sorghum flour in the blends increased. Protein values of the flours as depicted in Table 2 ranges from 2.09±0.11% to 5.30±0.39%. The percent protein of all the flours analysed were significantly different ($p < 0.05$. However, the addition of *okara* to the initial plantain–sorghum blends caused the corresponding rise in the protein of the flours. This could be as a result of the additive effect of *okara* flour protein [27%] on the plantain and sorghum flours [14]. The levels of protein in pure plantain and pure sorghum observed in this study showed that the fruit and cereal are low in protein and cannot meet adult protein diet need, which for a healthy adult is about 0.75 g per kg per day [34].

Crude fibre was determined to be 9.38±1.44%, and 12.20±2.30% in the 100% plantain and 100% sorghum respectively. The appreciable increase in crude fiber content of each flour supplemented with 5% *okara* observed from sample F to J affirms the claim that *Okara* is very rich in soy fibre [35].

From the Table 2, the fat content of 100% sorghum [3.56±0.37%] is higher than that 100% plantain [1.77±0.03%] and the fat content of composite flours significantly increased as the sorghum portion increases. This lower value of fat suggests a longer shelf life in terms of the onset of rancidity [36]. Also, the presence of sorghum and *okara* flours in plantain give an appreciable increase in fat contents of flour blends: this is as a result of effect of oil in *okara* a byproduct of soya bean [37]. Fat contributes greatly to the energy value of foods, slow down the rate of utilization of carbohydrate [38].

The flours differed significantly in their value of Carbohydrate ($p < 0.05$). Highest carbohydrate content was observed in 100 % Plantain (75.65±4.53%) while sample J had the lowest value (64.33±5.32%), this result is similar to the values reported by Khazrai, et al. [39], It is significant ($p < 0.05$) In the values, and the addition of *okara* flour to the blends caused reduction in carbohydrate. This confirmed that soybeans residue are poor sources of carbohydrate when compared to other legumes [40]. This study finding is similar to that of Okoye, et al [41] who observed a reduction in carbohydrate content (73.4% to 34.9%) of wheat-soybean flour as the proportion of soy flour increased.

The energy values of the composite flours, as shown, ranged between 305.16±14.87 kcal and 333.36±21.11 kcal, and varied significantly ($p < 0.05$). The addition of 5% *okara* to plantain – sorghum flour caused a.decline in the energy level of the composite flours.

3.2 Functional Properties

3.2.1 Bulk density (BD)

The result of the functional properties of the samples are presented in Table 3. Bulk density (BD) varied significantly ($P<0.05$) between sample A (0.45±0.02 g/mL) and sample J

(0.57±0.01 g/mL) There were a significant increase ($P<0.05$) in the bulk density of the composite flour with increase in the level of sorghum flour. The addition of *okara* flour caused a relative increase in the bulk density of the composite flour. The bulk density of sample A is similar to the findings of other researchers on 100% plantain flour [42,43]. Flours' particle size and density are factors influencing their bulk density which is an indication of the porosity of a product and determinant on the cost and choice of packaging material, raw material handling and application in wet processing in the food industry [44,45,46].

3.2.2 Water and oil absorption capacity

The water absorption capacity (WAC) of the *okara* fortified composite flours significantly ($P<0.05$) ranged between sample E (164.65±19.73%) the lowest and sample F (219.40±11.41%).the highest. it was observed that there was a reduction in WAC of the flour blends as the level of sorghum increased, but the addition of *okara* to the composite flour caused a corresponding increase in WAC of the flour blends due to its high content of protein. This observation confirms the report of [43,45,47] that the water absorption capacity of food materials is a function of its protein content. The loose structure of the starch polymer could be responsible for the high WAC and the compactness of the polymer structure might cause reduction in WAC [45,48]. This suggests that increase in water absorption in the blends can be useful in bakery products such as bread, cakes, cookies that requires hydration to improve dough handling characteristics The result of the 100% plantain flour in this study is higher than the one reported by Adegunwa et al. [49] who obtained 131.75 ± 8.84% WAC for 100% plantain flour. The oil absorption capacity (OAC) followed similar trend as water absorption capacity, decreasing with increase in the amount of sorghum. The OAC ranged between the lowest 96.45±3.46% (sample E) and the highest 148.65±14.35% (sample F). The OAC of flours is influenced by the quantity of protein in the flour which structure is made up of both hydrophilic and hydrophobic group [50]. Therefore, sample F with high OAC will be good for the production of bakery products as it will retain flavor and increase the mouthfeel of the product [49].

3.2.3 Swelling power (SP) and solubility index (SI)

In this study, sample E (100% sorghum flour) that contain the least protein value had the highest swelling power 9.97±2.02g/g while sample F with highest protein value had the lowest swelling power 5.87±1.02 g/g. because a high amount of protein in flour may hinder the starch granules accessibility to water hence reducing the swelling power [51,52]. Tester and Morrison [53], Moorthy and Ramanujam [54] reported that the swelling power of granules is an indication of the extent of associative forces within granule Swelling power is also a function of the ratio of amylose to amylopectin, and amylopectin is primarily responsible for granule swelling. The higher amylopectin contents in composite flour the higher the swelling power of composite flour. The swelling power obtained in this study for 100% plantain 6.48±1.74 g/g is lower than the values reported by Abioye, et al, [42] for 100% plantain flour (8.22 g/100 g) and this attributed to the variety of plantain used for the flour. The water solubility index commonly used to measure the amount of starch. Leaching of amylose is said to be responsible for solubility of starch in most starch-based products. The

Table 3. Effect of *okara* addition on the functional properties of the composite flour

Samples**	BD (g/cm^3)	WAC (%)	OAC (%)	SP (g/g)	SI (%)	WET (secs)
A	0.45±0.02^{a*}	216.00±8.63^{i}	147.10±18.65^{i}	6.48±1.74^{b}	36.60±6.60^{a}	122.00±9.60^{i}
B	0.48±0.04^{b}	200.45±4.17^{g}	134.85±16.70^{g}	7.85±0.89^{c}	36.88±8.30^{a}	97.67±10.67^{g}
C	0.51±0.01^{c}	192.80±2.55^{e}	122.50±12.45^{e}	8.23±1.60^{d}	37.00±5.90^{ab}	78.53±6.67^{e}
D	0.53±0.02^{d}	181.40±.42^{c}	105.05±7.04^{c}	9.12±0.94^{e}	37.22±7.06^{b}	53.40±7.40^{c}
E	0.56±0.03^{e}	164.65±19.73^{a}	96.45±3.46^{a}	9.97±2.02^{f}	37.433.23^{b}	27.33±2.13^{a}
F	0.46±0.01^{ab}	219.40±11.41^{j}	148.65±14.35^{j}	5.87±1.02^{a}	49.70±4.70^{c}	135.33±12.33^{j}
G	0.49±0.43^{bc}	204.56±19.4^{h}	136.85±11.03^{h}	6.93±1.47^{b}	49.93±5.40^{c}	110.50±11.00^{h}
H	0.52±0.02^{cd}	196.15±1.34^{f}	125.45±13.92^{f}	7.60±1.03^{c}	50.00±4.98^{c}	93.60±8.56^{f}
I	0.54±0.03^{de}	185.75±3.18^{d}	108.05±5.53^{d}	8.32±1.53^{d}	50.35±6.30^{cd}	69.50±4.05^{d}
J	0.57±0.01^{ef}	172.60±2.12^{b}	100.55±9.49^{b}	8.97±1.85d^{e}	50.53±8.13^{d}	46.82±3.92^{b}

**Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different 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[71.25P:23.75S:5K]; [H47.5P: 47.5S:5K]; I[23.75P: 71.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]*

Table 4. The mean scores for sensory evaluation

Sample**	Colour	Aroma	Taste	Texture	After Taste	Overall acceptance
A	$6.00\pm0.12^{ab*}$	$6.05\pm0{,}09^{ab}$	6.10 ± 0.08^{a}	5.95 ± 0.05^{b} 0.14^{abc}	6.45 ± 0.10^{ab}	6.80 ± 0.15^{ab}
B	6.60 ± 0.11^{b}	6.60 ± 0.11^{abc}	6.30 ± 0.08^{ab}	6.20 ± 0.07^{abc}	6.30 ± 0.05^{ab}	7.35 ± 0.12^{ab}
C	6.90 ± 0.08^{b}	6.60 ± 0.02^{abc}	5.85 ± 0.04^{a}	6.35 ± 0.04^{abc}	6.00 ± 0.07^{ab}	6.60 ± 0.04^{a}
D	6.10 ± 0.02^{ab}	6.35 ± 0.06^{abc}	6.30 ± 0.09^{ab}	6.50 ± 0.09^{abc}	6.65 ± 0.12^{ab}	6.65 ± 0.11^{a}
E	5.65 ± 0.06^{ab}	6.00 ± 0.12^{ab}	6.20 ± 0.03^{ab}	6.50 ± 0.12^{abc}	6.40 ± 0.11^{ab}	6.85 ± 0.08^{ab}
F	5.00 ± 0.04^{a}	5.45 ± 0.02^{ab}	5.95 ± 0.06^{a}	6.20 ± 0.03^{abc}	5.80 ± 0.04^{a}	6.35 ± 0.07^{a}
G	7.10 ± 0.11^{b}	7.40 ± 0.07^{c}	7.50 ± 0.09^{b}	7.10 ± 0.11^{c}	7.30 ± 0.11^{b}	7.85 ± 0.12^{b}
H	6.25 ± 0.09^{ab}	6.90 ± 0.09^{bc}	5.90 ± 0.05^{a}	5.55 ± 0.08^{a}	6.00 ± 0.03^{ab}	6.60 ± 0.06^{a}
I	6.05 ± 0.10^{ab}	6.60 ± 0.06^{abc}	6.80 ± 0.07^{ab}	5.65 ± 0.06^{ab}	6.30 ± 0.07^{ab}	6.50 ± 0.03^{a}
J	6.70 ± 0.07^{b}	6.45 ± 0.08^{abc}	5.65 ± 0.03^{a}	6.95 ± 0.12^{bc}	6.20 ± 0.12^{ab}	6.85 ± 0.05^{ab}

**Values are Mean±SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different 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[71.25P:23.75S:5K]; [H47.5P: 47.5S:5K]; I[23.75P: 71.25S:5K]; J[95S:0P:5K] P [Plantain Flour], S[sorghum Flour], K[Okara Flour]*

solubility index of the composite flour presented in Table 3 ranged from 36.60±0.60% to 50.53±0.00%.The solubility index of the flour blends increased slightly as amount of sorghum in the blends increased. Also addition of *okara* flour increased the solubility, According to Numfor [55], leaching is enhanced by hydrolysis to amylose during soaking. The higher the solubility index the better the reconstitution of the flour.

3.3 Wettability

Wettability is the time taken for samples to absorb water. The results ranged from 27.33±2.13 Sec to 135.33±12.33 Sec with the sample E possessing the lowest wettability. The wettability 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. This result revealed 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, this could probably due to the fact that *okara* must have changed the physical and chemical compositions of the plantain-sorghum flour and made it less susceptible to imbibe water [56].

3.4 Sensory Evaluation of Composite Flours

The sensory scores of a 20 – member panelists on the stiff dough [*amala]* produced from plantain - sorghum composite flours, and corresponding *okara* fortified flours as shown in Table 3 varied significantly (P<0.05) in all the parameters evaluated. There are slight significant (p < 0.05) difference in the rating of the panelist in terms of colour which confirmed the report of Summer and Nielsen [57] who reported that incorporation of 20% and above sorghum in flour formulation darkened the gruel colour. Sample G was rated the highest (7.10±0.11) while sample F [5.00±0.04] was rated neither liked nor disliked. There were overlapping differences in the aroma of the entire amala produced from the composite flour except for the significant differences (p < 0.05) that was observed between sample F and G having a mean score of 7.40±0.07 and 5.45±0.02 respectively. There were overlapping differences in the mean value of the amala texture except sample G having the highest mean value (7.10±0.13) was liked moderately and H lowest mean value [5.55±0.08] was rated neither liked nor disliked by the panelists. The results gotten from all the sensory evaluation agreed with Kyomugisha [58] on production and Characterisation of Bread from Euripus – Sorghum composite flour. As regards general acceptability, sample G was rated to have the highest overall acceptance. However other *amala* samples were rated above 6 points on the hedonic scale, indicating that *amala* produced from all the composite flours are organoleptically acceptable to the panelists.

4. CONCLUSION

Based on the results obtained from the study, fortification of plantain - sorghum composite flours with soymilk residue *(okara)* significantly increased the protein, fat, fibre and ash content of the flours and reduced their carbohydrate and energy values, The low-fat content of the composite flours suggest long shelf life of the products and also suitable for those that wish to maintain their body fat. The addition of *okara* had an effect on the functional properties of the plantain - sorghum flour samples. Fortified Flours had higher water and oil absorption capacity than their corresponding composite flours and this suggests that the improved WAC and OAC in the blends can be useful in bakery products such as bread, cakes, cookies that requires retention of flavour, better hydration to improve dough handling characteristics, and increase the mouthfeel of the products. 5% *okara* flour did not cause any appreciable increase in the bulk density of the corresponding plantain – sorghum flour. Generally, the results of the Sensory evaluation of the stiff dough (Amala) prepared from the flours were ranked to be moderately acceptable, however, the sensory panellist"s scores indicated that sample G stiff dough was more preferred by the panelist. Thus the results of the study indicated that composite flours produced by blending plantain, sorghum, and *Okara* together could serve as raw materials in food industries, and as staple foods in various households to combat hunger and problems on the African continent and developing countries.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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