Quality Evaluation of Swallow Meal Produced from Blends of Broken Rice and Bambara Groundnut Flour

N. Ivo[a], F.C. Ekwu[a], N.E. Efuribe[b], and O.J. Irem[a]
Department of Food Science and Technology,
Ebonyi State University, Abakaliki, Ebonyi, State, Nigeria
Food Technology Department,
Federal Institute of Industrial Research, Oshodi, Lagos State, Nigeria
ivongozika92@gmail.com

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Abstract

Owing to the quest for a nutrient-dense swallow meal with relative cost as well as enjoying local cuisines, there was a need to develop a swallow meal that would be acceptable while considering its nutritional content. Hence, this study is focused on the functional, pasting properties, proximate and sensory attributes of broken rice flour blended with Bambara groundnut flour in the ratios of 100:00 (A), 80:20 (B), 60:40 (C), and 50:50(D) The functional, pasting, proximate, and sensory characteristics were evaluated with standard procedure. The functional properties ranged from 265 to 37%, 0.57-0.82g/ml, 1.67-2.15, and 64.00-71.50% for water absorption capacity, bulk density, swelling capacity, and dispersibility respectively. The pasting properties ranged from 221.7 to 287.58 RVU, 148.71 to 225.00 RVU, 759.12 to 958.50 RVU, 52.04 to 83.21 RVU, 86.33 to 113.04 RVU 5.86 to 6.08 minutes and 85.70 to 87.50 °C for peak, trough, final breakdown viscosity, peak time and pasting temperature. The proximate composition ranged from 5.48 to 6.99%, 0.71 to 1.83%, 9.00 to 16.24%, 1.20 to 4.56%, 1.03 to 2.00%, 68.43 to 82.59% for moisture, ash, protein, fat, crude fibre, carbohydrate respectively. The sensory results ranging from 6.17 to 8.20, 6.48 to 8.73, 6.28 to 8.50, 5.27 to 7.91, 4.54 to 8.28, 5.06 to 8.03 were obtained for texture, mouldability appearance, ease of swallow, aroma and overall acceptability respectively. Significant difference was noted across all parameters except for breakdown viscosity, setback viscosity, peak-time, and pasting temperature in pasting properties.

***Keywords**: Broken rice grain, Bambara groundnut, functional properties, pasting properties, proximate, sensory*

Introduction

In Nigeria, swallow meals are staple foods typically consumed with different types of soups (Becky 2017). They are rich sources of calories as they can be made from different carbohydrate-dense foods such as roots, tubers, and cereals.

Rice (*Oryza sativa*) is one of the cereal leading food crops of the world and a staple food of over approximately half of the world's population (Singh *et al*., 2003; Zhu et al. 2018). Its carbohydrate content ranges from 78 to 90% (Purseglove, 1992) and it's among the cereals with high calorie content (FAO, 2017). There has been an acceleration in rice production due to high demand from the rising population, hence, rice plays a major role in alleviating the world's poverty and hunger level. In Nigeria, cereal is widely grown in different geopolitical regions and its consumption has risen tremendously due to the rise in population (Nkang *et al*., 2006). Globally, approximately 600 million tons of rice are harvested annually, as Chen et al. (2012) reported. Likewise, in Nigeria, there has been accelerated growth in rice consumption with an estimated 2.1 million tons consumed annually. However, during the process of rice milling, broken rice grains are generated as a result of the mechanical and heat stress the paddy grains undergo. Hence, there is a reduction in the milling yield and general quality of the rice which is of economic loss to the farmers (Payman et al. 2007). As reported by USDA (2009), broken rice grains are referred to as milled rice grains which are 75% (three quarter) less the length of unbroken rice grains and these are termed "low quality" as they do not meet the standard specification of rice; hence, considered a by-product. Most local mills in Nigeria do not possess the advanced equipment required to limit the breakages of the rice paddy during milling, this gives rise to broken grains occurrence which are highly under-utilized because of their appearance and quality. As such, the less privileged who reside around the milling factories usually go for the substandard broken rice grains which are sometimes sold at minimal cost or dumped around the mill factory, since they can barely afford the unbroken rice grains. However, value can be added to the broken rice grains by processing it into semi-finished, finished products and also through fortification.

Bambara groundnut is an underutilized leguminous seed mostly found in sub-Saharan Africa (Mahmudul *et al*., 2021). The plant thrives in unfavourable weather conditions; thus, it is one of the crops used in fighting food insecurity. Bambara groundnut is cultivated primarily for its seed, the seeds can be boiled, consumed freshly, or. In some regions of West Africa, the seeds are eaten in different forms, it can be boiled into a pudding, the dried seeds can be processed into flour and prepared into a steamed paste (Okpa), roasted and ground for soup preparation also, the fresh seeds can be eaten as a snack when boiled (Adu-Dapaah and Sangwan 2004; Kaptso *et al*. 2007; Okpuzor et al. 2010). According to Azman *et al*. (2019), Bambara groundnut is a nutrient-dense legume also known as a "complete food" because of its rich macronutrient and bioactive properties which are also beneficial to the body. It contains ~64.4% carbohydrate, 6.5% fat, 23.6% protein, and 5.5% fibre as well as minerals such as K (11.44–19.35 mg/100 g), Fe (4.9–48 mg/100 g), Na (2.9–12.0 mg/100 g), and Ca (95.8–99 mg/100 g), (Paliwal et al., 2021; Lin Tan *et al*., 2020). Despite its nutritional benefits, Bambara groundnut has some setbacks such as strong beany flavour, hard-to-cook phenomenon due to the hard coat, and anti-nutritional components which prevent the nutrients from being absorbed into the body (Oluwatofunmi et al., 2015).

In most Sub-Saharan Africa, bambara groundnut (*Vigna subterranean*) can be used to fortify carbohydrate-dense foods from cereals, roots, and tubers to combat protein energy malnutrition. Likewise, blending the broken rice with Bambara groundnut flour will boost not only the nutritive value of the product but will also benefit people who are gluten intolerant, diabetic, and children who require protein for growth development.

However, there is limited research on the use of bambara groundnut flour blended with broken rice for the production of swallow meals. Hence, this study aims to evaluate the quality effect of blending bambara groundnut and broken rice flour to produce a swallow meal.

2.0 Materials and Methods

2.1 Source of Materials

The broken rice grains and bambara groundnut used for this experiment were purchased from Abakaliki Rice Mill and Meat Market, respectively.

2.2 Preparation of Samples

2.2.1 Production of rice flour

The broken rice grain was dry-cleaned to remove stones and any extraneous material. The dry-cleaned rice was washed, drained, and sun-dried. The dried rice was milled with a hammer mill and sieved with sieves to obtain rice flour

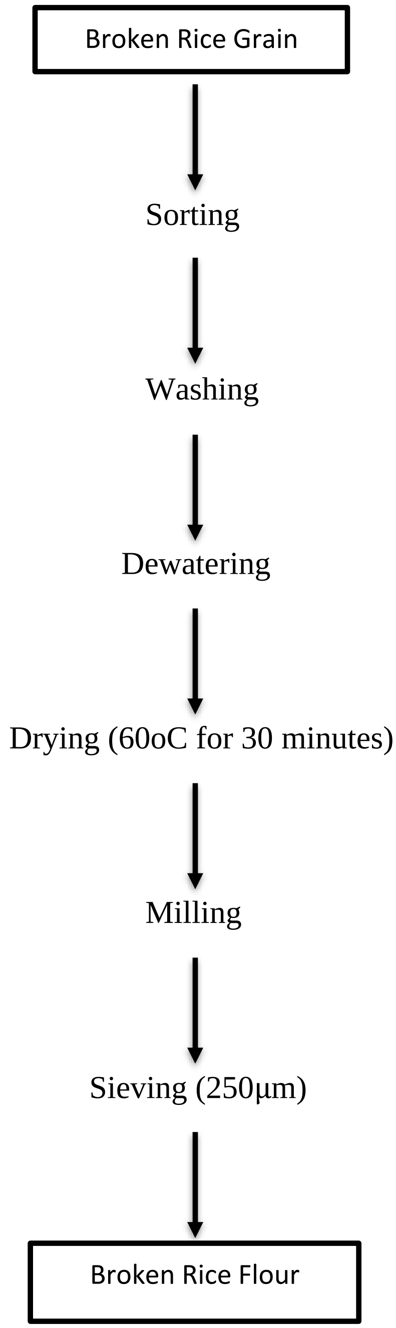
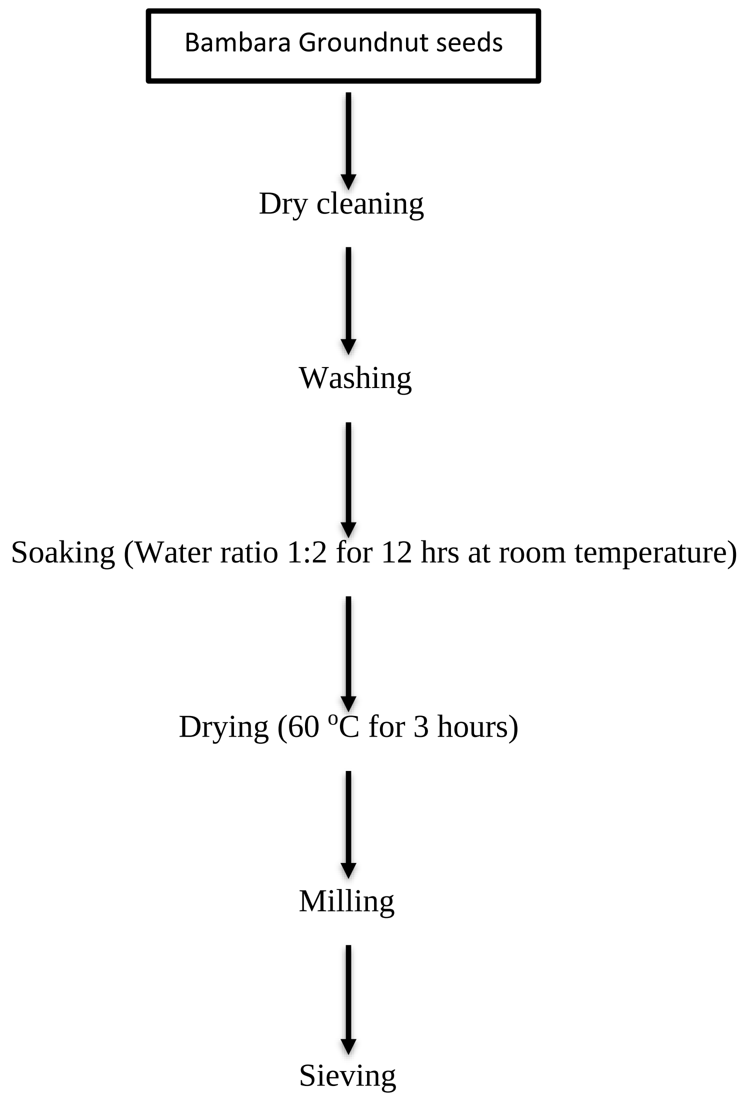


Fig 1: Flowchart for the production of rice flour production

2.2.2 Production of Bambara groundnut flour

Bambara groundnut flour was processed according to the method described by Nwosu (2013). The Bambara groundnut was sorted to remove extraneous materials and damaged seeds. The seeds were washed and then soaked in tap water at a ratio of 1:2 (seeds: waters) for 12 hours at room temperature it was manually dehulled and oven-dried at 60° C for 3 hours, the dried seeds were ground using a hammer Mill. The milled Bambara groundnut flour was passed through a sieve to obtain fine flour.



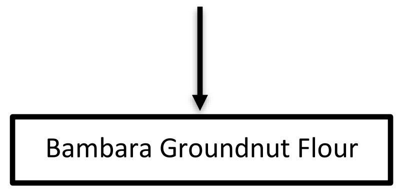


Fig 2: Flow chart for the production of Bambara groundnut Flour Source: (Nwosu, 2013).

2.2.3. The Ratio of the Flour Sample Blends

Table 1: The ratio of the flour sample blends.

S/N	Sample	Rice flour (%)	Bambara groundnut flour (%)
1	A	100	0
2	B	80	20
3	C	60	40

2.2.4. The Preparation of Swallow Meal from the Flour samples

To prepare the swallow meals, the various flour blends were dispersed into boiling water and cooked with continuous stirring over the fire till a gelatinous mass was obtained and then cooled.

3.0 CHEMICAL ANALYSIS

3.1 Functional Properties

3.1.1 Bulk density

This was determined by filling 10 ml of an empty measuring cylinder with the sample. Thereafter, the measuring cylinder was tapped severally on the laboratory bench until no visible reduction was noticed on the sample level. Then, the measuring cylinder was weighed, and the volume of the sample was also noted. The packed bulk density was calculated as the weight of the tapped sample per unit volume.

3.1.2 Swelling

The swelling Capacity of the flour samples was determined using the method described by Kaur *et al.* (2011). 1g of each flour sample was measured into a pre-weighed empty centrifuge tube and then mixed with 10 ml of distilled water. It was heated for 30 minutes at 60°C while being agitated uninterruptedly. Thereafter, the tube was removed from the water bath, cleaned, dried, and further centrifuged further at 3200 rpm for 30 minutes after cooling at room temperature. The swollen sample was weighed after the supernatant was decanted. Then, the swelling capacity was expressed as the ratio of the weight of the swollen sample paste to the weight of dry flour sample.

3.1.3 Water absorption capacity

Water absorption capacity was determined according to the method described by Sathe *et. al.* (1982). 1g of flour sample was measured into a centrifuge tube; the sample was mixed thoroughly with 10 ml distilled water for 30 seconds and allowed to stand for 30 minutes at ambient temperature. The sample was then centrifuged at 4000rpm for 30 minutes after which unabsorbed water was decanted and measured. Water absorption capacity was expressed as volume (ml) of water absorbed per gram of sample.

3.1.4 Dispersibility

The dispersibility of the sample was determined by measuring 10 g of flour sample into 100 ml of a measuring cylinder, then distilled water was added up to 100 ml volume, and the mixture was vigorously agitated and allowed to rest for 3 hours. The volume of settled solution was noted and subsequently deducted from 100. The difference between the two values was reported as percentage dispersibility (Adegunwa *et. al.*, 2017).

3.2 Pasting Properties

Flour pasting properties were evaluated using Rapid Visco Analyzer (RVA 4500; Perten Instruments, Sweden). About 25 ml of water was added to 3g sample to produce 12% flour suspension in the RVA canister; the canister paddle was put in place and its blade was trotted through the suspension for about 8 times to ensure proper mixing of the suspension. The canister, fitted with the paddle, was then placed in the machine as recommended. The 12 minutes profile was used; idle time and temperature were 1 minute and 50 ^oC, respectively, sample was heated from 50 ^oC to 95 ^oC in 3 minutes, 45 seconds, held at 95 ^oC for 2 minutes, 30 seconds, and then cooled back to 50 ^oC over 3minutes 45 seconds period, this was followed by 2 minutes period when the temperature was maintained at 50 ^oC. The following pasting parameters were obtained: peak viscosity, hot paste viscosity, breakdown viscosity, final viscosity, setback viscosity, pasting temperature, and peak time.

3.3.0 Moisture content

Moisture contents of the bread samples were determined by oven drying method (AOAC, 2000). Five grams of well-mixed sample was accurately weighed into a clean and dried moisture can (W1). The can was placed in an oven at 105 ^oC for 3 h weighed and placed back in the oven until a constant weight was obtained. Then the can was placed in the desiccator for 30 min to cool. After cooling, it was weighed again until three consecutive constant weight was obtained (W2).

The percentage of moisture was calculated as indicated in Equation (1)

$$\%Moisture = \frac{W1 - W2}{Sample\ weight} \times 100 \qquad (2)$$

WhereW1= Initial weight of crucible + Sample

W2= Final weight of crucible + Sample

3.3.1 Ash content

The ash content of the bread samples was determined using the method of AOAC (2000). A clean, empty crucible was placed in a muffle furnace (Carbolite, ELF11/14B, S336RB) England at 600 °C for 1 hour, cooled in desiccators, and then the weight of the empty crucible was noted (W1). One gram of the sample was weighed into the crucible (W2). The sample was ignited over a Bunsen burner until it was charred. Then the crucible was placed in the muffle furnace at 550 ^oC

for 4 hours. The appearance of a grey white ash indicated the complete oxidation of all organic matter in the sample. After ashing, the furnace was switched off. The crucible was cooled and weighed (W3).
The percentage of ash was calculated as indicated in Equation (2)

$$\%Ash = \frac{Difference\ in\ weight\ of\ ash}{weight\ of\ sample} \times 100 \quad (3)$$

3.3.2 Crude fat

The crude fat of the samples was determined by ether extract method using Soxhlet (Thermo scientific EME3100/CEB, UK) apparatus (AOAC, 2000). Approximately 1 g of moisture-free sample was wrapped in filter paper; it was then placed in a fat-free thimble and then introduced into the extraction tube. The weighed, cleaned, and dried receiving beaker was filled with petroleum ether and fitted into the apparatus. The water and the heater were turned on to start extraction. After 4-6 siphoning the ether was allowed to evaporate and the beaker was disconnected before the last siphoning. The extract was then transferred into a clean glass dish with ether washing and the evaporated ether on water bath. Then the dish was placed in an oven at 105 °C for 2 hours and then allowed to cool in a desiccator. The amount of crude fat was calculated as shown in equation below

$$\%crude\ fat = \frac{weight\ of\ ether\ extract}{weight\ of\ sample} \times 100 \quad (4)$$

3.3.3 Protein content

Protein in the sample was determined by the Kjeldahl method as described by AOAC (2000). The samples were digested by heating with concentrated sulphuric acid (H2SO4) in the presence of a digestion mixture. The mixture was made alkaline. Ammonium sulphate thus formed the released ammonia which was collected in 2% boric acid solution and titrated against standard HCl. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor (6.25) and the amount of protein was calculated as indicated in equation 5 and 6

$$\%\ Crude\ protein = 6.25 * \times \%N \quad (5)$$

$$\%N = \frac{(Sample\ titration - Blank\ reading) \times N \times 0.014 \times Dilutionof\ sample}{weight\ of\ sample} \quad (6)$$

3.3.4 Crude fibre content

Crude fibre was determined by the method described by AOAC (2000). A moisture free and ether extracted sample of crude ash was made of cellulose and digested with dilute H2SO4 and then with dilute KOH solution. The undigested residue was collected after digestion and ignited. The loss in weight after ignition was recorded as crude fibre.

$$\%\text{crude fibre} = \frac{W1 - W2}{W0} \times 100 \quad (7)$$

Where; W0 = sample weight
W1 = weight of the dried sample
W2 = the re–weighed sample

3.3.5 Total carbohydrate content

Total carbohydrate was calculated by difference i.e. Total Carbohydrate = (100 – (% moisture +% crude protein +% crude fat + % crude fibre + % ash)).

3.4 Sensory evaluation

The swallow meals produced from the different flour blends were evaluated after production for their organoleptic properties. Twenty member panelists were drafted to assess the qualities of the different samples based on aroma, colour, taste, mouldability, and general acceptability using the 9-point Hedonic scale (1 and 9 representing "extremely dislike'' and "extremely like'', respectively) as described by Iwe (2002).

3.0 RESULT AND DISCUSSION

3.1 Functional properties of rice flour blended Bambara groundnut flour

Table 2: Functional properties of rice flour blended with Bambara groundnut flour

Sample	Water absorption capacity (%)	Bulk density (g/ml)	Swelling capacity (%)	Dispersibility
A	265^{d}	0.57^{d}	2.15^{a}	71.50^{a}
B	295^{c}	0.73^{c}	1.90^{b}	69.50^{b}
C	315^{b}	0.76^{b}	1.76^{c}	67.50^{c}
D	370^{a}	0.82^{a}	1.67^{d}	64.00^{d}

Values with different superscripts are significantly different (P<0.05). The values are means of three (3) replicates.

Samples A represent 100% Rice Flour, B is 80% Rice flour blended with 20% Bambara groundnut Flour, C is 60% Rice Flour blended with 40% Bambara groundnut flour and D is 50% Rice Flour blended with 50% Bambara groundnut flour

The result of the functional properties is presented in Table 2. The values obtained for water absorption capacity ranged from 265 to 370, with sample D having the highest water absorption capacity and sample A having the lowest value. The result shows that the addition of bambara groundnut flour to the rice flour affected the amount of water absorption capacity. This could be due to the high protein content of bambara flour, which contains hydrophilic parts that enhance water uptake (Lawal and Adewale 2004).

The bulk density of the flour samples ranged from 0.57 to 0.82 g/ml as shown in table 2 above, with sample D having the highest bulk density value (0.82 g/ml) and sample A having the least bulk density value (0.57g/ml). There was a significant difference ($p<0.05$) among the mean of the flour samples. This study showed that an increase in the inclusion level of Bambara groundnut flour was attributed to an increase in bulk density. The result obtained from this work is lower than the one obtained from Oluwole *et al.* (2016). The higher the bulk density, the denser the packaging material required. It also reflects the relative volume of the packaging material required. According to Efuribe *et al*. (2018), samples with high bulk density are associated with ease of dispersibility and a reduction in paste thickness.

The evaluation of how individual flour molecules disperse and homogenize with fluid is linked to dispersibility. The dispersibility of the flour samples ranged from 64.00 to 71.50%, as shown in Table 2 above, with sample A having the highest value of dispersibility (71.50%) and sample D having the least value of dispersibility (64.00%). There was a significant difference ($p<0.05$) among the mean of the samples. An increase in the inclusion of Bambara groundnut flour led to a decrease in the result obtained from this work. It is higher when compared to Oluwole *et al.* (2013). It has also been discovered that flours with higher dispersibility have a higher potential to reconstitute in water (Asaam *et al*.,2018). Higher dispersibility is an indication that the sample will be free of lump formation tendencies during swallow meal production.

The ability of a starch to absorb water determines its swelling capacity. The range of swelling capacity values for the flour samples was from 1.67% to 2.15%, with sample A having the highest value (2.15%) and sample D having the lowest value (1.67%). There was a significant ($p<0.05$) difference observed in the mean values of the samples. The decrease in swelling capacity could be attributed to the formation of complexes between starch and proteins. Variations in the composition of starch granules in flour blends may also account for the differences (Efuribe *et al*., 2018).

3.2 Pasting properties of rice flour blended with Bambara groundnut flour

Table 3: Pasting properties of rice flour blended with Bambara groundnut flour

Sample	Peak viscosity	Trough viscosity	Final viscosity	Breakdown viscosity	Setback viscosity	Peak time	Pasting temperature
A	287.58^{a}	204.38^{a}	952.25^{a}	83.21^{a}	113.04^{a}	5.91^{a}	85.70^{a}
B	285.55^{a}	206.05^{a}	953.39^{a}	79.50^{a}	111.75^{a}	5.98^{a}	87.35^{a}
C	277.04^{a}	225.00^{a}	958.50^{a}	52.04^{a}	94.50^{a}	5.86^{a}	86.39^{a}
D	221.75^{b}	148.71^{b}	759.12^{b}	73.05^{a}	86.33^{a}	6.08^{a}	87.50^{a}

Values with different superscripts are significantly different ($P<0.05$). The values are means of three (3) replicates.

Samples A represent 100% Rice Flour, B is 80% Rice flour blended with 20% Bambara groundnut Flour, C is 60% Rice Flour blended with 40% Bambara groundnut flour and D is 50% Rice Flour blended with 50% Bambara groundnut flour.

Pasting results from the changes that occur upon further heating after gelatinization. The swelling capacity of starchy food samples before their physical breakdown is known as peak viscosity. The peak viscosity shown in Table 3 ranged from 287.58 to 221.75, sample A recorded the highest value and sample D had the lowest. A significant difference was not noted among samples A, B, and C. However, sample D showed a significant difference ($p<0.05$). Ikegwu *et al*. (2010) reported that a high peak viscosity correlates with starch water binding ability. Therefore, the results obtained from this study are suitable for swallow meals.

The trough viscosity ranged from 148.71 to 225.00 RVU as shown in Table 3 above, with sample C having the highest trough viscosity and sample D having the lowest trough Viscosity. There was no significant difference ($P>0.05$) among samples A, B, and C, but it varies in sample D. Studies have shown that the trough viscosity of different rice starch cultivars ranges from 133.60 to 227.33 RVU (Ashogbon and Akintayo 2012). The result obtained from this work is in line with the previous study. The significantly higher trough viscosity observed in this study indicates the tendency of the flour samples to breakdown during cooking.

The final viscosity varied from 759.12 to 958.50 RVU. Sample C had the highest final viscosity value, and sample D had the lowest value. Samples A, B, and C were not significantly different from each other ($P>0.05$), but significantly different from sample D. Final viscosity can be used to evaluate flour quality since it indicates how well it forms a paste once cooked and cooled. It also provides a measure of the paste's resistance to shear force during mixing (Adebowale *et al*., 2005). Hence, the high final viscosity obtained is suitable for producing swallow meals due to its high viscosity.

The result of the breakdown viscosity obtained from this work range from 52.04 to 83.29 RVU, with sample A having the highest value and sample C having the least. There was no significant difference ($P>0.05$) among the mean of the samples. The results suggest that the bambara groundnut flour as a blend with the rice flour affected the breakdown Viscosity. The variation in result will be attributed to the brains of bambara groundnuts being added to the rice flour in different ratios.

The setback viscosity value ranged from 86.33 to 113.04 RVU, with sample A recording the highest value and sample D having the lowest value. The statistical analysis carried out on this work showed that there was no significant difference ($p>0.05$) among the mean of the samples. Setback viscosity is associated with cohesiveness; this implies that the result obtained will be suitable for fufu production since it possesses an attribute of cohesion.

The peak-time value ranged from 5.86 to 6.08 minutes, with sample D having the highest value of peak time and sample C sample having the least. There was no significant difference ($P>0.05$)

among the mean of the samples. Peak time indicates the energy costs required to cook a sample. According to Adebowale (2005), peak time is the measure of cooking time the result indicates that the energy cost requirements will be relatively low.
A range of 85.70 to 87.38 °C (Table 3) was recorded for pasting temperature. Sample D has the highest value of pasting temperature, and sample A has the least value of pasting temperature. No significant difference (P>0.05) was observed among the mean of the samples; the results suggest that the increase in the inclusion level of Bambara groundnut flour attributed to an increase in the pasting temperature. Pasting temperature is a measure of the minimum temperature required to cook a given food. The low pasting temperatures exhibited by the different flour samples suggest that they easily formed pastes, hence being more suitable for swallow meals.

Table 4: Proximate composition of rice flour blended with Bambara groundnut flour

Sample	Moisture	Ash	Protein	Fat	Crude Fibre	CHO
A	**5.48±0.01^{d}**	**0.71±0.01^{d}**	**9.00±0.01d**	**1.20±0.21 d**	**1.03±0.00c**	**82.59±0.21 d**
B	**6.09±0.02^{c}**	**1.14±0.00^{c}**	**11.22±0.98 c**	**2.43±0.33 c**	**1.52±0.05b**	**77.62±1.34 c**
C	**6.68±0.00^{b}**	**1.58±0.01^{b}**	**14.40±0.57 b**	**3.93±0.03 b**	**1.94±0.01a**	**71.50±0.64 b**
D	**6.99±0.01^{a}**	**1.83±0.03^{a}**	**16.24±0.04 a**	**4.56±0.01 a**	**2.00±0.00a**	**68.43±0.04 a**

Values with different superscripts are significantly different (P<0.05). The values are means of 2 replicates

The proximate composition findings can be found in Table 4 above. The moisture content results ranged from 5.48% to 6.99%. Sample D had the highest value, while Sample A had the least value. The mean of the samples differed significantly (P <0.05). It was observed that an increase in the inclusion of bambara groundnut flour increased the moisture content. Lower moisture content is associated with a longer shelf life for a food product (Olaleye et al., 2018). Hence, the range obtained from this work shows that the flour sample would last longer.

The ash content ranged from 0.71% to 1.83% with sample D having the highest value and sample A had the lowest value. Ash content depicts the mineral content of a food material. The ash content of legumes has been reported to be high (Olapade *et al*., 2014). This can be attributed to the higher mineral content in Bambara groundnut flour, as the mineral content increases with the increase in the inclusion of Bambara groundnut. A higher ash content may indicate increased nutritional value. The protein content varied from 9.00% to 16.24%, with sample D having the highest value and sample A having the least. An increase in the inclusion of Bambara groundnut flour increased the protein content. This is consistent with previous studies, which reported that legumes are associated with higher protein content compared to cereals (Okin *et a*l., 2021).

The result of the fat content varies from 1.20% to 4.56%. Sample A had the highest ranking and sample D had the least. A significant difference (P<0.05) was observed among the mean of the samples. Fat content also increased with the increase in the proportion of Bambara groundnut flour. This could be attributed to the higher fat content in legumes compared to rice flour (Adebowale *et al.*, 2005). Crude fibre, which represents the indigestible portion of the flour, showed a significant increase as the proportion of Bambara groundnut flour increased. There was no significant difference between sample Cand D. However, it varies with samples A and B (P>0.05). Studies have shown that legumes contain a higher fibre content than rice (Hannington *et al*., 2020).

The results of the carbohydrate content ranged from 68.43 to 82.59 %, with sample A having the highest value and sample D had the least. Statistically, the mean of the samples differed (P <0.05). It was observed that an increase in the inclusion of bambara groundnut flour decreased the carbohydrate content. According to the values obtained, it will be a good source of energy.

Table 5: Sensory Evaluation of rice flour blended with Bambara groundnut flour

SAMPLE	TEXTURE	MOULDABILITY	APPEARANCE	EASE OF SWALLOW	AROMA	OVERALL ACCEPTABILITY
A	8.20± 0.01a	8.73±0.06a	8.50±0.01a	7.19±0.02a	8.28±0.02a	8.03±0.06a
B	7.87±0.01b	7.73±0.01b	7.98±0.01b	7.20±0.02a	7.79±0.02b	7.32±0.02b
C	7.47±0.02c	7.74±0.01c	6.98±0.01c	6.68±0.01b	6.74±0.01c	7.29±0.01b
D	6.17±0.01d	6.48±0.02d	6.28±0.02d	5.27±0.01c	4.54±0.02d	5.06±0.13c

Table 5 shows the sensory results of the flour samples. The sensory evaluation results varied significantly.

Texture and mouldability, which give an overview of the elasticity and ease of shaping the swallow meal, ranged from 6.17 to 8.20 and 6.48 to 8.73, respectively. The highest ratings were noted in sample A, and sample D had the least. A significant difference (P<0.05) was observed among the mean of the samples. These findings suggest that the increase in the inclusion of bambara groundnut flour in the rice flour decreased the textural and moulding attributes of the swallow meal. This could be a result of high protein and fat contents of legumes.

The appearance results varied from 8.50 to 6.28. Sample A recorded the highest value, and sample D had the least. It was observed that the score decreased as the proportion of bambara groundnut flour increased, which could be as a result of the browning colour. The browning colour is a result of a maillard reaction between the carbohydrate and high protein content of bambara groundnut during heating (Olapade *et al.* 2014). However, it is still acceptable since some of our swallowed meals, such as amala, also appear to be brown in colour.

Ease of swallow is associated with swallowing the moulded swallow meal without difficulty. The result ranged from 7.19 to 5.27, with sample A having the highest value and sample D having the least. There was no significant difference (P>0.05) among the mean of samples A and B but varied in samples C and D. The decrease observed in the ease of swallow is due to the increase in the inclusion of Bambara groundnut flour.

Aroma is associated with the flavour of food. The results obtained ranged from 8.28 to 4.54. Sample A had the highest aroma value, and sample D had the lowest value. A significant difference (P<0 05) was observed among the mean of the samples. The decrease in the aroma score could be related to the strong beany flavour of legumes (Adesokan *et al*, 2011).

The overall acceptability also varied among the samples. Sample A had the highest overall acceptability value, and sample D had the least. There was no significant difference (P>0.05) among samples B and C, but varies with samples A and D.

4.0. CONCLUSION AND RECOMMENDATION

The result obtained from this work indicated that the incorporation of Bambara groundnut flour into the broken rice flour at different ratios affected the functional, pasting, proximate, and sensory attributes. The samples vary significantly (P<0.05) across parameters with an exception in the breakdown viscosity, setback viscosity, peak time, and pasting temperature. It can be concluded that Broken rice flour blended with bambara groundnut flour is suitable for swallow meal production especially sample C (Broken rice flour (60): Bambara groundnut flour (40), since the functional, pasting, proximate, and sensory evaluation are associated with the processing requirement, nutritional content and the general acceptability of the swallow meal.

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