Effect of Partial Bran and Hull Restoration on the Quality Characteristics of *Ogi*: A Fermented Maize Starch Gruel

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DOI: 10.56201/rjfsqc.v9.no3.2023.pg114.127

Abstract

The effect of partial bran and hull restoration on the physicochemical, functional, proximate, mineral and sensory properties of Ogi was investigated. Bran and hull was restored at graded levels of 5,10,15,20 and 25% to the ogi. There was significant (p<0.05) increase in pH (3.24 – 3.72) and total solid (0.7 – 3.5%), while viscosity ranged from 126.75 – 131.05 Pa.s. Bulk density decreased significantly (p<0.05) from 0.20 – 0.28 g/ml, with increase in water absorption capacity (3.02 – 4.02 g/g) solubility (7.10 – 14.15%) and swelling power (10.71 – 11.00g). Gelation time (1.82 – 1.49 min) and temperature (72.20 – 70.85ºC) did not differ significantly (p<0.05). There was significant (p<0.05) decrease in moisture (8.85 – 4.70%) and carbohydrate (76.86 – 73.40%) and increase in protein (6.50- 8.4%), fat (4.98 – 6.79%), ash (0.40-0.90%) and crude fiber (2.5- 6.04%). Zinc, potassium, magnesium and iron content increased significantly (p<0.05) from 0.40 – 1.40, 56.31 – 81.49, 17.89 – 34.71 and 7.01 - 10.57 mg/100 respectively. Samples had varying degrees of likeness for the sensory attributes. The control and sample B with 5% bran and hall had significantly (p<0.05) the highest degree of likeness for all attributes. The restoration of up to 5% is recommended based on the qualities evaluated.

Key Words: *Ogi, Bran and Hull, physicochemical, functional, proximate, mineral and sensory properties*

1. Introduction

Ogi is an important stable fermented cereal gruel or liquid porridge produced from maize, sorghum or millet grains (Kiin-Kabari *et al*., 2018). *Ogi* is seen as one of the cheapest and popular foods. It is a meal that enhance the breakfast milk production for nursing mothers and recovery diet for the sick (Afolayan *et al.*, 2010).

Ogi is also known as *akamu* in the South- south and South eastern part of Nigerian. Its traditional production process involves soaking of grains in excess cold water for 2-3 days, decanting of the soaking water, washing, wet milling and wet sieving using muslin cloth. Therafter, the filtrate is allowed to sediment and fermented for 2-3 days to yield wet *ogi*, which is a sour, starchy sediment (Obinna-Echem *et al*., 2015; Ohehen and Ikenebomah, 2017). During the processing of *ogi*, nutrients such as protein and minerals are lost which reduces the nutritional quality of the final product (Afolabi *et al*., 2015). According to Nuss and Tanumihardjo, (2010), maize contains 72% starch, 10% protein and 4% fat, providing a density of about 365 kcal/100g when compared to rice and wheat but less in protein content.

Cereal bran is a nutritional store house of the grains. The insoluble dietary fibres of corn are comprised of cellulose (c. 200-280 g/kg), hemicellulose (c. 700 g/kg) and lignin fraction (c. 10 g/kg) (Rose *et al.,* 2010). All millet brans have phytonutrients, viz: tannins, flavonoids, anthocyanins along with phytic acids and phenols (Kumari *et al.,* 2013), Benefits of these phytonutrients and their antioxidant potential is widely known. The chemical composition of cereal bran is highly complex and the multiple beneficial effects of cereal bran can be exploited by incorporating it into the daily diet, besides regular nutrients like protein, vitamin, mineral and fat, it contains many bioactive compound and phenolic compounds (Owuno *et al*., 2023). Some of these nutrients are lost during the wet sieving process during *ogi* processing. Partial bran and hull restoration is an attempt to achieve a balance between nutrient retention and the sensory attributes of *ogi*; while also producing a cereal based gruel in the mode of Quaker oat with increase in the fibre content.

Ogi is not an adequate source of micro and macro nutrients, sieving *ogi* leads to loss of nutrients. (Owuno *et al*., 2023). An attempt has been made to mitigate the nutrient loss through by-passing the sieving process, while by-passing this unit operation enhanced nutrient retention, it also had a negative effect on the sensory attribute (Owuno *et al*., 2023).

This study therefore is aimed at striking a balance between nutrient retention and organoleptic properties by investigating the effects of partial and graded bran restoration on the physicochemical, functional, proximate, mineral and sensory attributes of *ogi*.

2. MATERIALS AND METHODS

2.1 Production of *Ogi* Powder

Ogi powder was produced as shown in Figure 1. The grains were cleaned and sorted by removing the pest-infested grains and discoloured ones. It was steeped for 72 h at room temperature and the steep water was decanted while the fermented grain was washed with potable water and wet-milled. It was then wet sieved and the slurry was allowed to sediment and fermented for 24 h. Excess water was decanted and the slurry was bagged and dewatered to get the *ogi* cake. The *ogi* cake was then dried at 50ºC for 12 h. The derived residue (bran and null) was also dried at 50^0C for 12 h. The residue was restored at graded levels as to the *ogi* power as shown in Table 1. The blends were milled using a commercial attrition mill and packaged for analysis.

2.2 Levels of Bran and Hull Restoration

The bran and hull restoration process were achieved by adding the dry bran and hull to the dry ogi at the ratios shown in Table 1.

Table 1 Formulation of *Ogi* – Residue Blend

Sample code	Substitution levels (g)	
	***Ogi* flour**	**Residue (bran and hull)**
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20
F	75	25

2.3 Determination of the Physiochemical Properties of *Ogi*-Bran and Hull Blends

Total solid, pH and viscosity were determined by the method described by AOAC (2012).

2.4 Determination of the Functional Properties of *Ogi*-Bran and Hull Blends

The method described by Obinna-Echem *et al.*; (2023) was used to determine bulk density. Gelation time and temperature were determined by the method described by Chavan *et al*., (2010). Water absorption capacities, solubility and swelling power were determined by the method described by Dwiani, (2014).

2.5 Determination of Proximate Composition of *Ogi*-Bran and Hull Blends

Proximate compositions were determined according to the methods of the Association of Official Analytical Chemist (AOAC, 2012).

2.6 Mineral Analysis of *Ogi*-Bran and Hull Blends

The minerals: zinc, potassium, magnesium and iron content were determined with the Atomic Absorption Spectrophotometer (Buck Scientific, Model, 2010), (AOAC, 2012).

2.7 Sensory Evaluation of *Ogi*-Bran and Hull Blends Porridge

Sensory evaluation of the *ogi* was carried out using the method described by Owuno *et al.*, (2023). The *ogi*-residue powder was reconstituted and made into porridge by the addition of equal amount of water to form slurry and then stirred with hot water at 100ºC. Twenty memberssemi-qualified panelists of the department of Food Science and Technology, Rivers State University, Nigeria were selected based on experience/familiarity with *ogi* for sensory evaluation. *Ogi* with residue restored at graded levels were compared to *ogi* prepared from control (sieve *ogi*). The samples were evaluated for colour, aroma, taste, mouthfeel (texture) and overall acceptability. Each attribute was rated on a 9-point hedonic of 1 to 9, with 1 representing dislike extremely, 5 represented neither liked nor disliked and 9 representing liked extremely.

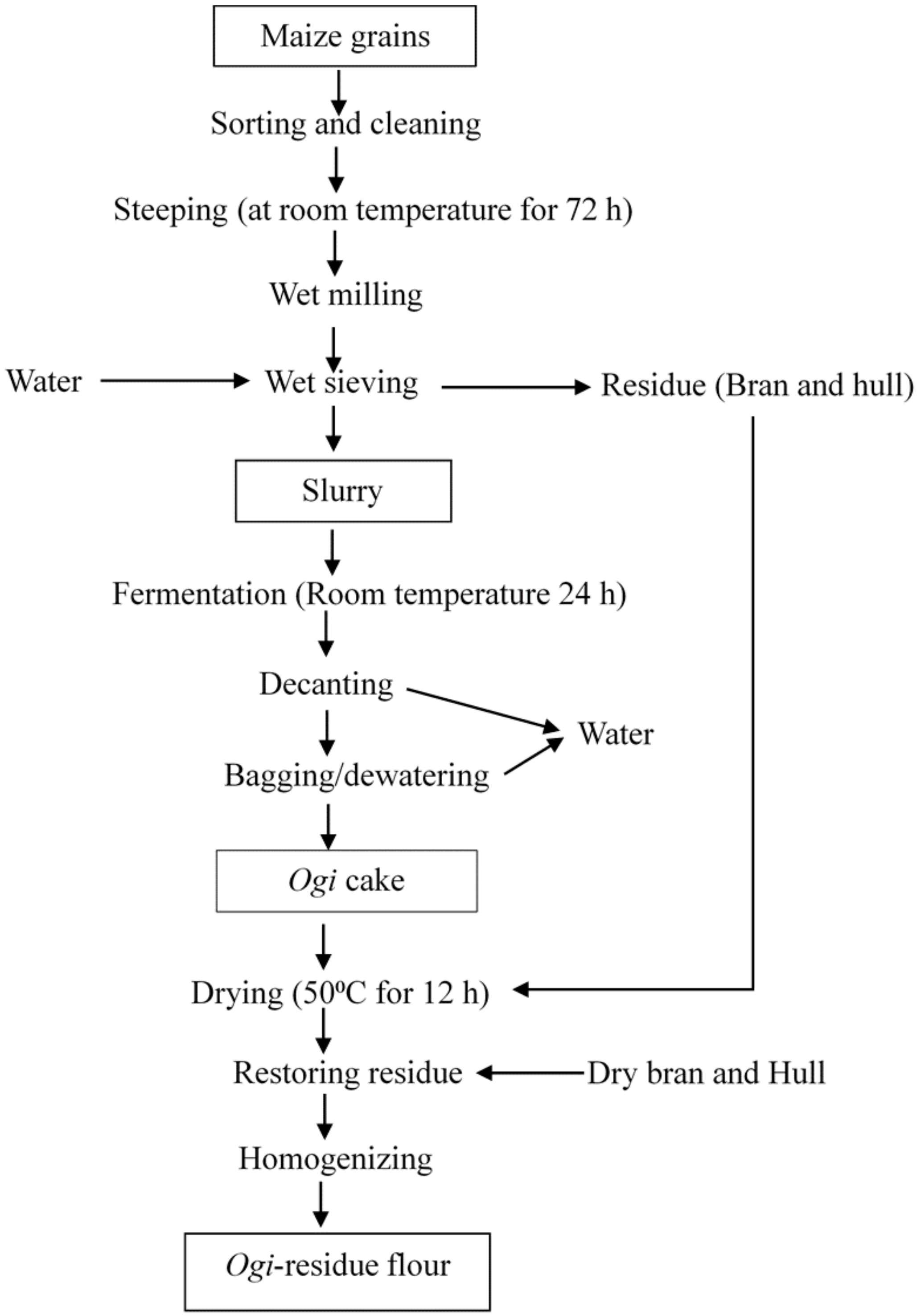

Fig 1. Production of *Ogi*-Residue (Bran and Hull) Flour

2.8 Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) and Tukey's test to separate the mean among the sample using statistical packaged for social science (SPSS) version 26.0.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Ogi-Bran and Hull Blends

Table 2 showed the functional properties of the ogi-bran and hull flour blends. Functional properties are important physicochemical properties of food, that reflects the complex interaction between the structures, molecular conformation, compositions and physicochemical properties of food components with the nature of the environment and condition in which these are measured and associated (Suresh and Samsher, 2013).

Table 2. Functional properties of the *ogi*-bran and hull blends

Sample	Bulk Density (g/ml)	Water Absorption Capacity (g/g)	Solubility %	Swelling Power (g/g)	Gelation Temperature (°C)	Gelation Time (min)
A	$0.28^{a} \pm 0.00$	$3.02^{b} \pm 0.00$	$7.10^{d} \pm 0.28$	$10.71^{a} \pm 0.24$	$72.20^{a} \pm 0.00$	$1.82^{a} \pm 0.69$
B	$0.26^{ab} \pm 0.02$	$3.26^{b} \pm 0.34$	$9.00^{c} \pm 0.00$	$11.11^{a} \pm 0.00$	$70.25^{c} \pm 0.07$	$1.28^{a} \pm 0.00$
C	$0.24^{bc} \pm 0.00$	$4.00^{a} \pm 0.00$	$10.15^{c} \pm 0.21$	$12.75^{a} \pm 0.07$	$70.50^{c} \pm 0.14$	$1.29^{a} \pm 0.00$
D	$0.23^{bcd} \pm 0.00$	$4.01^{a} \pm 0.00$	$11.95^{b} \pm 0.07$	$13.25^{a} \pm 0.21$	$70.45^{c} \pm 0.07$	$1.43^{a} \pm 0.00$
E	$0.22^{c\ d} \pm 0.01$	$4.02^{a} \pm 0.00$	$14.15^{a} \pm 0.35$	$11.00^{a} \pm 4.24$	$70.85^{b} \pm 0.07$	$1.49^{a} \pm 0.00$
F	$0.20^{c} \pm 0.01$	$4.03^{a} \pm 0.00$	$15.02^{a} \pm 0.84$	$15.10^{a} \pm 0.14$	$69.85^{d} \pm 0.07$	$1.38^{a} \pm 0.00$

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at ($p<0.05$)
A= 100% *Ogi* flour
B= 95% *Ogi* flour: 5% bran and hull
C= 90% *Ogi* flour: 10% bran and hull
D= 85% *Ogi* flour: 15% bran and hull
E= 80% *Ogi* flour: 20% bran and hull
F= 75% *Ogi* flour: 25% bran and hull

Bulk density of the *ogi*-residue blends decreased significantly ($p<0.05$) from 0.20 - 0.28 g/ml. Sample A (control) was observed to be the highest and sample F the lowest. All the samples were not significantly different ($p<0.05$) from one another. The reduction of the bulk density was due to the restoration of bran and hull. This result agreed with Owuno *et al*., (2023), who reported that the addition of bran and hull decreased the bulk density. Bulk density is important in determining the packaging requirement, material handling and application in processing food industry (Alsenaien *et al*., 2015). However, foods high in bulk density is a good physical attribute when determining the mixing quality of a particular matter (Chukwu *et al*., 2018).

Water absorption capacity ranged from 3.02 - 4.03 g/g. Sample A had significantly ($p<0.05$) the lowest value of 3.02 g/g and sample F had the highest value of 4.03 g/g. The presence of bran and hull increased the water absorption capacity of the *ogi*. This study agreed with Owuno *et al.,* (2023), reported an increase in the water absorption capacity in wheat –fermented maize starch residue blend. The hydrophilic nature of the water might have contributed to the increase in the water absorption capacity of the *ogi* samples with bran and hull.

Solubility index of the samples increased significantly ($p<0.05$) from 7.10% in sample A to 15.02% in sample F. Sample E and F were significantly different ($p<0.05$) from sample A B, C, D and E. The increase in solubility is attributable to the increasing soluble nutrient in the *ogi* constituent. This is in agreement with work carried out by Oppong *et al*., (2015) on composite flour. High solubility can show high digestibility of the food which may indicate excellent use for infant feeding.

Swelling power ranged from 10.71g in sample A to 15.02 g for sample F. All the samples were not significantly different ($p>0.05$) from each other. Swelling index of flour granules is an indication of the extent of associative forces within the granules (Adebowale *et al*., 2012). Bhosale and Vijayalakshim, (2022) reported an increase in the swelling power capacity of probiotic treated with rice bran. This may be as a result of the addition of bran and hull to the *ogi*.

Gelation temperature ranged from 69.85 - 72.20ºC. Sample F had significantly ($p<0.05$) the least temperature while sample A had the highest value. Samples A was significantly different ($p<0.05$) from the other samples. The decrease in the gelation temperature was due to the addition of bran and hull, as the addition of residue increased, the gelation time decreased. The reduction in gelation temperature could be due to the water absorbed by the flour which is an index for gelatinization (Tang *et al*., 2004). The presence of residue obviously led to a dilution of the starch content which is an important factor in the gelatinization process.

Gelation time values ranged from 1.29 - 1.82 min with sample B having the lowest time frame and sample A having the highest time frame. Sample A was significantly ($p<0.05$) different from the other samples. Decrease in gelation time was as a result of the addition of bran and hull to the *ogi*. This result is in agreement with Owuno *et al.,* (2023) reported a decrease in the gelation time due to the retention of bran and hull.

3.2 Physiochemical Properties of the Porridge from *Ogi*-Bran and Hull Blends

Table 3 showed the physiochemical properties of the *ogi*-bran and hull blends. Total solid content (%) increased significantly ($p<0.05$) from 0.70 in sample A to 3.45% in sample F. The increase in the total solid content indicates an increase in the soluble nutrients. The pH varied significantly ($p<0.05$) from 3.24 - 3.72 for sample A and sample F respectively. All samples were significantly different ($p<0.05$) from one another. This is due to the addition of residue to the *ogi*. The pH in this study is lower than the pH of millet *ogi* reported by Obinna-Echem *et al.,* (2023). There was a decrease in the viscosity of the *ogi*-residue porridges, though not significantly ($p>0.05$) different. The values ranged from 126.75 - 130.36 Pa.s for sample A and sample D respectively. The viscosity in this study is higher than the viscosity reported by Bolaji *et al*., (2014) for *ogi* from maize at 80ºC. Samples with bran and hull were lower than the sample with control (sample). This decrease is due to the presence of the residue; a source of insoluble dietary fibre. Ozyurt and Otles, (2016) reported whole grain cereals contain greater quantities of insoluble dietary fibre and that the type of dietary fibre, either soluble or insoluble define their physical behaviour in water. The presence of the residue will definitely reduce the interaction within starch granules thereby leading to a weak gel network upon gelatinization thereby lowering the viscosity.

Table 3. Physicochemical properties of the *ogi*-bran and hull blends

Sample	Total Solids (%)	pH	Viscosity (Pa.s)
A	$0.70^{e}\pm0.00$	$3.24^{f}\pm0.01$	$130.35^{a}\pm1.48$
B	$1.83^{d}\pm0.04$	$3.31^{e}\pm0.01$	$131.05^{a}\pm4.88$
C	$2.85^{c}\pm0.07$	$3.48^{d}\pm0.01$	$130.15^{a}\pm0.92$
D	$3.10^{b}\pm0.00$	$3.53^{c}\pm0.01$	$126.75^{a}\pm1.34$
E	$3.25^{ab}\pm0.07$	$3.65^{b}\pm0.00$	$129.75^{a}\pm3.46$
F	$3.45^{a}\pm0.07$	$3.72^{a}\pm0.01$	$127.90^{a}\pm1.98$

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at ($p<0.05$)
A= 100% *Ogi* flour
B= 95% *Ogi* flour: 5% bran and hull
C= 90% *Ogi* flour: 10% bran and hull
D= 85% *Ogi* flour: 15% bran and hull
E= 80% *Ogi* flour: 20% bran and hull
F= 75% *Ogi* flour: 25% bran and hull

3.3 Proximate Composition of *Ogi*-Bran and Hull Blends

There was significant ($p<0.05$) variations in the proximate composition (%) of the *ogi*-bran and hull flour blends as shown in Table 4. The restoration of bran and hull brought a reduction in the moisture content from 4.70 in sample F to 8.85 in sample A. This results agreed with Owuno *et al*., (2023) who reported that the low moisture content could be attributed to the presence of bran and hull. Usman *et al*., (2015) also reported a decrease in the moisture content of biscuit made from 50% maize bran due to the high fiber content because the higher the fiber the lower the water retaining capacity of the flour, and this is an indication for a longer shelf life as high moisture encourages the development of contaminating microorganisms, whose growth and activities cause spoilage in foods (Okafor and Ugwu, 2014). Flour becomes increasingly sensitive to fungus growth, taste modification and enzymatic activity when the moisture level climbs over 14.0% (Batool *et al*., 2012). Protein content of the *ogi*-residue samples ranged from 6.50 - 8.45% with sample A having significantly ($p<0.05$) the lowest value and sample F having the highest value. This study showed an increase in the protein content. Usman *et al*., (2015) reported an increase in the protein content of biscuit produced from maize bran flour. Carvajal- Millan *et al*., (2007) reported a protein content of 11.8% for maize bran. This increase in protein of the *ogi* samples with the increase in addition of the residue is an improvement on the quality of the product.

Table 4 Proximate composition (%) of the *ogi*-bran and hull blends

Sample	Moisture	Protein	Ash	Fat	Crude Fibre	Carbohydrate
A	$8.85^{a}\pm0.07$	$6.50^{a}\pm0.00$	$0.40^{bc}\pm0.00$	$4.98^{f}\pm0.00$	$2.45^{f}\pm0.07$	$76.86^{a}\pm0.06$
B	$7.82^{b}\pm0.11$	$6.90^{b}\pm0.00$	$0.30^{c}\pm0.29$	$5.19^{e}\pm0.00$	$3.29^{e}\pm0.13$	$76.35^{ab}\pm0.21$
C	$5.67^{c}\pm0.10$	$7.35^{c}\pm0.07$	$0.60^{abc}\pm0.00$	$5.58^{d}\pm0.00$	$3.74^{d}\pm0.06$	$76.98^{a}\pm0.31$
D	$5.55^{cd}\pm0.08$	$7.85^{b}\pm0.07$	$0.70^{abc}\pm0.00$	$6.40^{c}\pm0.00$	$4.30^{c}\pm0.01$	$75.26^{b}\pm0.22$
E	$5.05^{de}\pm0.07$	$8.28^{a}\pm0.04$	$0.80^{ab}\pm0.00$	$6.57^{b}\pm0.00$	$5.52^{b}\pm0.07$	$73.83^{c}\pm0.25$
F	$4.70^{e}\pm0.28$	$8.45^{a}\pm0.07$	$0.90^{a}\pm0.00$	$6.79^{a}\pm0.00$	$6.04^{a}\pm0.09$	$73.40^{c}\pm0.71$

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at ($p<0.05$)
A= 100% *Ogi* flour
B= 95% *Ogi* flour: 5% bran and hull
C= 90% *Ogi* flour: 10% bran and hull
D= 85% *Ogi* flour: 15% bran and hull
E= 80% *Ogi* flour: 20% bran and hull
F= 75% *Ogi* flour: 25% bran and hull

Ash content of the *ogi*-bran and hull samples in this study was relatively low, but the samples with bran and hull had higher ash content. The values ranged from 0.30 in sample B to 0.90 in sample Muzzamal *et al*., (2021) reported that the ash content of maize with bran and hull represented inorganic residues after the combustion of organic material which contains a small amount of minerals. Rose *et al*., (2010) reported ash content of 0.6% in maize bran. The ash content of foods is indicative of the total minerals (Owuno *et al.*, 2023) This study thus shows an increase in ash content with bran and hull restoration. Fat content of the *ogi*-bran and hull samples increased significantly ($p<0.05$) from 4.98 - 6.79% with sample A having the lowest value of 4.98% and sample F having the highest value of 6.98%. The increase in fat content across the samples indicates that the fat was more in bran and hull. The results of the fat content agreed with Asuk *et al*., (2016) who reported that maize bran contained 11.6% fat.
Crude fibre content of the samples increased significantly ($p<0.05$) with the addition of the residue and the values ranged from 2.45 - 6.04% for sample A and sample F respectively. An increase in the crude fibre content in wheat-corn bran and wheat-wheat bran biscuit was reported by Adebowale *et al.*, (2012). Fibre is very important in diet due to its numerous health benefits. Carbohydrate content of the *ogi*-bran and hull samples ranged from 73.40 - 76.86% as sample F had significantly ($p<0.05$) the lowest value due to the presence of maize residue and sample A (control) had the highest value due to the absence of maize residue. This result agrees with Owuno *et al*., (2023) who reported a decrease in the carbohydrate content of *ogi* with bran and hull retention. Decreases in carbohydrate content with increase in protein is desirable in *ogi* which is mostly a starchy meal.

3.4 Sensory Attributes of *Ogi*-Bran and Hull Porridges

The result of sensory evaluation is as presented in Figure 2. The aroma, colour, taste, texture and overall acceptability of the *ogi*-bran and hull porridges had varying degrees of likeness from neither like nor dislike to like very much. Sensory analysis is an important criterion for assessing quality in the development of new products and for meeting the consumer requirement. There was significant decrease in the degree of likeness of the sensory attributes with increase in the addition of bran and hull. Aroma of the *ogi* sample ranged from 6.50 - 7.35 for sample F and sample A respectively, indicating like slightly to like moderately. Colour varied significantly (p<0.05) from 5.95 in sample F to 7.65 in sample A, indicating neither like nor dislike to like moderately. The attribute of taste had degree of likeness between like slightly to like moderately corresponding to the values of 6.80 and 7.25 for sample F and sample A respectively. Texture had degree of likeness between neither like nor dislike and like very much which corresponds to the values 5.60 and 8.15 respectively, for sample F while sample A. Overall acceptability ranged from 6.18 – 7.60 for sample E and A respectively, representing like slightly to like moderately. The control (sample A) and sample B (with 5% level of substitute) had similar degree of likeness that was significantly (p<0.05) different from all others and this scenario cuts through all the attributes suggesting that pap made from *ogi* flour with residue (bran and hull) at 5% restoration can be prepared without a negative effect on the sensory attributes.

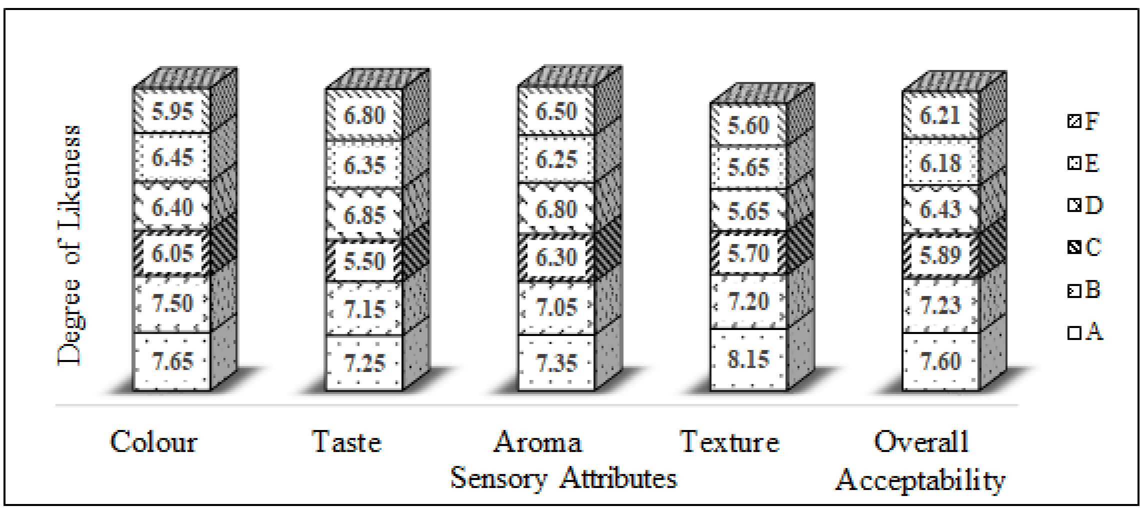

Figure 2. Degree of Likeness of the Sensory Attributes of the *Ogi*-Bran and Hull Porridges.
Each box in the column represents each sample with the mean scores.
A= 100% *Ogi* flour
B= 95% *Ogi* flour: 5% bran and hull
C= 90% *Ogi* flour: 10% bran and hull
D= 85% *Ogi* flour: 15% bran and hull
E= 80% *Ogi* flour: 20% bran and hull
F= 75% *Ogi* flour: 25% bran and hull

3.5 Mineral Content of *Ogi*-Bran and Hull Blends

Table 5 showed the mineral content (mg/100g) of the *ogi*-bran and hull blends. Zinc content of the *ogi* varied significantly (p<0.05) from 0.40-1.40 mg/100g with sample A having the lowest value and sample D having the highest value. Zinc is an example of a micro mineral which is needed in much smaller amount but are still very necessary for good health. Zinc mineral content increased with the addition of bran and hull. Inadequate zinc intake has been associated with severe malnutrition, increased disease condition and mental impairment (Wardlaw *et al*., 2004). Shakpo and Osundahuni, (2016) reported an increase in the mineral content of maize-cowpea flour blends as the supplementation level of cowpea increased.

Table 4. Mineral composition (mg/100g) of the *ogi*-bran and hull blends

Sample	Zinc	Potassium	Magnesium	Iron
A	$0.40^{f}\pm0.00$	$56.31^{f}\pm0.00$	$17.89^{f}\pm0.01$	$7.01^{f}\pm0.00$
B	$0.95^{d}\pm0.00$	$65.91^{e}\pm0.00$	$19.94^{e}\pm0.01$	$9.54^{c}\pm0.00$
C	$0.97^{c}\pm0.00$	$71.49^{d}\pm0.00$	$24.48^{d}\pm0.01$	$7.37^{e}\pm0.01$
D	$1.40^{a}\pm0.00$	$78.04^{b}\pm0.00$	$34.43^{b}\pm0.00$	$10.29^{b}\pm0.00$
E	$0.90^{e}\pm0.00$	$75.89^{d}\pm0.00$	$34.71^{a}\pm0.00$	$9.33^{d}\pm0.00$
F	$1.03^{b}\pm0.01$	$76.44^{c}\pm0.00$	$31.44^{c}\pm0.01$	$10.57^{a}\pm0.00$

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at p<0.05
A= 100% *Ogi* flour
B= 95% *Ogi* flour: 5% bran and hull
C= 90% *Ogi* flour: 10% bran and hull
D= 85% *Ogi* flour: 15% bran and hull
E= 80% *Ogi* flour: 20% bran and hull
F= 75% *Ogi* flour: 25% bran and hull

Potassium content varied significantly (p<0.05) from 56.31 - 81.49 mg/100g with sample A having the lowest value of 56.31 mg/100g and sample C having the highest value of 81.49 mg/100g. Potassium is an example of macro nutrient which the body require in large amount. Potassium is required to maintain the osmotic balance of the fluid including the pH of the body. It also plays important role in the control of control and nerve irritability, glucose absorption and retention of protein during growth. The addition of bran and hull indicated an increase in the potassium content of the *ogi* (Aderinola and Adeome, 2022).

There was significant (p<0.05) increase in the magnesium content of the *ogi*-bran and hull blends. The values ranged from 17.89 - 34.71 mg/100g, with sample A having the lowest value and sample E having the highest value. Magnesium belong to the macro nutrient mineral which is required in large amount by the body. The addition of the bran to the *ogi* sample led to an increase in the magnesium content of the *ogi*. This study agreed with Aderinola and Adeome, (2022) who reported that increase of the bran content increased the magnesium content of ogi.

Iron content of the *ogi*-bran and hull samples ranged from 7.01 - 10.57 mg/100g. All the samples were significantly different ($p<0.05$) from one another. The addition of bran and hull increased the iron content of the *ogi*. Inadequate iron intake has been associated with severe malnutrition, increased disease condition and mental impairment (Wardlaw *et al*., 2004). Shakpo and Osundahuni, (2016) reported an increase in the mineral content of maize-cowpea flour blends as the supplementation level of cowpea increased.

CONCLUSION

This study showed decrease in bulk density, increase in water absorption capacity, solubility and swelling power of the samples with no significant ($p<0.05$) difference in the gelation temperature and time. There was significant ($p<0.5$) increase in the total solid, pH, viscosity protein, ash, crude fibre and fat; and mineral contents of the samples with increase in bran and hull addition. Partial bran and hull restoration at 5% level had similar degree of likeness with the control in all the sensory attributes. The nutrient enhancement and acceptability at 5% level of partial bran and hull restoration, strikes a balance between nutrient retention and sensory quality, thus indicating that *ogi* with enhanced nutrient can be prepared with residue restored at 5% level of substitution.

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