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Evaluation of some quality attributes of ‘ogi’ bran, water yam and pigeon pea flour blends and their stiff dough

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ABSTRACT

The physicochemical, functional and anti-nutritional properties of ‘ogi’ bran, water yam and pigeon pea flour blends, and sensory properties of their stiff dough were investigated. The simplex centroid mixture design was used to obtain ten blends from ‘ogi’ bran flour (OBF), water yam flour (WYF) and pigeon pea flour (PPF). Various ratios of the flours were blended and analysed for physicochemical, functional and anti-nutritional properties. The flour blends were then prepared into stiff dough for sensory evaluation using a 50-member sensory panel. There were significant ($p < 0.05$) differences in the proximate and mineral composition of the flour blends. The protein content of the blends ranged from 5.19% in control sample (100% WYF) to 20.98% (100% PPF), and increased as the proportion of PPF increased in the blends. Calcium content of the blends increased with an increase in the proportion of PPF while magnesium and iron content increased with the proportion of WYF. The bulk density increased as PPF increased in the formulation. Wettability (32.00 - 96.00 s) and dispersibility (19.50-71.00%) increased as the inclusion of WYF increased. Solubility index decreased as the inclusion of OBF increased. Water absorption capacity decreased as WYF decreased. Least gelation capacity increased as the addition of PPF and OBF increased in the formulation. Cooked pastes from composite blends of OBF, WYF and PPF compared favourably with control sample in terms of sensory attributes.

Keywords – ‘Ogi’ bran, Nutrient, Functional, Physiochemical, Sensory Properties

INTRODUCTION

The role of whole grain products in reducing the risk of degenerative chronic diseases has been reported (Ragae and Abdel-Aal, 2006). Cereal products are good sources of dietary fibre and many bioactive components such as ligands, phenolic acids, phytochemicals, minerals, tocopherols and tocotrienols (Ragae and Abdel-Aal, 2006).

Hence, whole grain flours and/or fortified flours have been advocated for the production of health-enhancing or functional foods (Ragae and Abdel-Aal, 2006).

‘Ogi’ is a staple food in West Africa and is commonly eaten by the vulnerable group such as infants, convalescents and the aged (Ponka *et al.*, 2015; Bolaji *et al.*, 2017). According to Akinrele and Edward (1971),

over 10 million Nigerians living in southwestern Nigeria consumed 'ogi'. It is therefore not surprising that 'ogi' is currently being produced at both domestic and industrial levels. Its preparation involves the retaining of starch obtained traditionally from the endosperm of fermented maize grains and the discarding of other components of maize, such as the pericarp or hull, germ and pedicle, which are sources of important nutrients. For example, while both the embryo and endosperm contain proteins, the germ proteins are superior in quality as well as quantity (Sofi *et al.*, 2009). The discarded component, commonly known as 'eri' (Yoruba), is referred as 'ogi' bran in this paper. 'Ogi' bran is often regarded as a waste which is at times used to feed animals. 'Ogi' bran, as a municipal solid waste, could be an important source of greenhouse gas emission in Nigeria (Kofoworola, 2016). However, based on the composition of bran and germ, 'ogi' bran is a potential good source of fibre and other important micronutrients. Consumption of bran has been associated to a number of health benefits such as laxative and stool-bulking ability, anti-carcinogenic effect and hypocholesterolemia effect (Mallillin *et al.*, 2008). Bran with lesser coarseness and ash content, higher protein as well as other beneficial components could be incorporated in human diet and used in the production of functional foods (Yadav *et al.*, 2012).

Water yam (*Dioscorea alata*) belongs to the neglected crops and many constraints limit its production. It is higher in protein and mineral than *Dioscorea rotundata*, the most widely consumed yam variety in Nigeria (Okigbo and Nwakammah, 2005). In comparison with other yam varieties, water yam contains less sugar and possesses an extended shelf life which enables its availability during scarcity period (Udensi *et*

al., 2008). The low sugar content makes it desirable in the formulation of food products for the diabetics.

Pigeon pea is one of the most drought-tolerant legumes and about the only crop that gives some

grain yield during dry spells when other legumes such as field beans will have wilted and perhaps dried up (Odeny, 2007). It is a good source of protein (18-30%), and therefore valuable in the alleviation of protein malnutrition in developing countries, where protein availability is about one-third of its normal requirements (WHO/FAO 2003; Odeny, 2007). It occupies a very important place in human nutrition and it has been used to enrich cereals (Fasoyiro *et al.*, 2010; Hassan *et al.*, 2011).

The objective of the work was to determine the physicochemical, functional and anti-nutritional properties of 'ogi' bran-water yam-pigeon pea flour blends, and to evaluate the sensory properties of stiff dough prepared from the flour blends.

MATERIALS AND METHODS

Materials

Water yam (*Dioscorea alata*) tubers and maize (*Zea mays*) were obtained from Osiele market in Abeokuta, while pigeon pea (*Cajanus cajan*) seeds were obtained from Bodija market in Ibadan, Nigeria.

Methods

Preparation of 'ogi' bran flour (OBF)

A modification of the method described by Akingbala *et al.* (1981) was used for 'ogi' manufacture. Maize grains (10 kg) were soaked in warm water at 50 °C for 48 h. The grains were wet ground using locally manufactured attrition grinding machine at medium speed for 7 min. The supernatant was decanted and the overtail ('ogi' bran)

collected. 'Ogi' bran was dried at 60 °C to 11% moisture content in a cabinet dryer (Genlab). The dried bran was milled using a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, Serial No. 950401) (FRISCH) with 0.25mm sieve to obtain 'ogi' bran flour (OBF).

Preparation of water yam flour (WYF)

Water yam flour (WYF) was prepared according to the method described by Babajide *et al.* (2008). The yam tubers were peeled, washed, sliced into flakes and blanched in water bath (Clifton, England) at 50 °C for 2 h. After blanching, the water yam slices were steeped in the same water for 24 h. The water was drained and the slices dried in Genlab cabinet dryer at 60 °C. Dried water yam slices (11% moisture content) were dry milled using locally manufactured attrition milling machine and sifted using 250 µm sieve.

Preparation of pigeon pea flour (PPF)

Pigeonpea flour (PPF) was prepared according to the method of Gayle *et al.* (1986). Pigeon pea was sorted, boiled in water for one minute and soaked in water for one hour. The seeds were dehulled, blended (1:2 w/v) in a Waring blender to a slurry, dried at 75 °C to a moisture content of about 11%, ground with a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, Serial No. 950401) to pass through a 250 µm sieve (Endecotts Ltd, England).

Preparation of flour blends

Simplex centroid mixture design was used to generate the blending ratios. The flour blends comprising of pigeon pea, 'ogi' bran and water yam flours were mixed

homogenously in different ratios as shown in Table 1.

Determination of proximate composition

The proximate composition of the flour blends was determined using AOAC (2010). Available carbohydrate was determined by subtracting the sum of moisture, protein, fat, ash, crude fibre as a percentage from 100.

Determination of mineral composition

The mineral (calcium, magnesium, phosphorus and iron) content was determined by atomic absorption spectrophotometry. The ash obtained from the muffle furnace (product of the ash content determination) was dissolved in 10 mL of concentrated HCl. The mixture was heated on a steam bath and the dissolved ash was filtered into a 100 mL volumetric flask and made up to volume with distilled water. The mineral content was determined using an atomic absorption spectrophotometer (Thermo scientific S series Model GE 712354). Sodium and potassium were determined by flame photometric method (AOAC, 2010).

Determination of anti-nutrients

Phytate was determined using the procedure outlined by Wheeler and Ferrel (1979). Tannin content was determined using the Folin-Dennis colorimetric method described by Griffiths and Jones (1977) and trypsin inhibitor was determined using AOAC (2010).

Determination of pH

The pH of the samples was determined using AOAC (2010). Sample suspension of 20 % (w/v) flour was prepared in 10 mL distilled water and its pH was measured at 22 °C using a pH meter.

Determination of colour

The colour of the formulated flour blends were done in triplicates using Minolta Chroma meter (CR-410). The instrument was calibrated with the user's supplied black and white plate calibration standard that was used for zero and white calibration settings respectively. Readings obtained from the flour samples were displayed as L*, a* and b* colour parameters according to the CIELAB system for colour measurement. According to Szabo *et al.* (2016), the L* value refers to the lightness of the sample (0=black; 99=white), a* value refers to the redness of the sample (in +60 direction red, in -60 direction green) and the b* value gives the yellowness of the sample (in +60 direction yellow, in -60 direction blue).

Determination of functional properties

The functional properties determined were bulk density, wettability, dispersibility, swelling power, solubility index, water absorption capacity, and least gelation concentration.

The bulk density was determined according to the method described by Baljet *et al* (2004). The sample (50 g) was put into a 100 mL graduated cylinder and tapped 20 - 30 times. The bulk density was calculated as weight per unit volume of sample.

Table 1: Blending ratio of the flour

Formulation/Sample ID	‘Ogi bran flour	Water yam flour	Pigeonpea flour
A	0	100	0
B	50	50	0
C	50	0	50
D	66.66	16.67	16.67
E	0	50	50
F	16.67	66.66	16.67
G	16.67	16.67	66.66
H	33	33	33
I	100	0	0
J	0	0	100

The wettability of the flour sample was determined according to the method described by Nwosu *et al* (2011). About 1 g of sample was added into a 25 mL graduated cylinder with a diameter of 1cm. A finger was placed over the open end of the cylinder which was inverted and clamped at a height of 10 cm from the surface of a 600 mL beaker containing 500 mL of distilled water. The finger was removed and the rest material allowed to be dumped. The wettability was the time required for the sample to become completely wet.

The dispersibility was determined according to the method described by Ohizua *et al.* (2017). Ten grams of each sample was suspended in 200 mL measuring cylinder and distilled water was added to reach the 100 mL mark. The set up was stirred vigorously and allowed to settle for 3 hr.

The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility.

The method described by Leach *et al.* (1959) was used to determine the swelling power and solubility index. One gram of sample was weighed into 100 mL conical flask, hydrated with 15 mL of distilled water and shaken for 5 min. The conical flask with its contents was put in a shaking water bath maintained between 80 and 85 °C for 40 min. After heating, the sample was quantitatively transferred into centrifuge tube by washing with 7.5 mL distilled water and centrifuged at 1,500×g for 20 min. The supernatant was decanted into a pre-weighed moisture can and dried at 100 °C to a constant weight. The sediment was weighed, and the swelling power and solubility calculated as follows:

$$\text{Swelling power} = \frac{\text{weight of sediment}}{\text{sample weight} - \text{weight of solution}}$$

$$\% \text{ Solubility index} = \frac{\text{weight of soluble}}{\text{weight of sample}} \times \frac{100}{1}$$

The method described by Baljet *et al* (2004) was used to determine the water absorption capacity. About 1 g of sample was mixed with 10 mL of distilled water, kept at ambient temperature for 30 min and centrifuged for 10 min at 2,000×g. The water absorption capacity was expressed as percent water bound per gram of the sample. The least gelation concentration was determined using the method of Baljet *et al* (2004). The flour dispersions of 2 – 30 % (w/v) at an interval of 2 % were prepared in 5 mL distilled water and heated to 90 °C for 1 h in a water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2°C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

Preparation of stiff porridge and sensory evaluation

Sixty grammes of each flour blend was reconstituted into paste, poured into boiling water contained in a stainless pot placed over a gas flame. Stirring of the flour paste was continued in the pot until a stiff porridge was obtained. Due to differences in the ratio of the flour blends, the volume of the boiling water and the cooking time varied from 150-200 mL and 5-7 min, respectively. A 50-member panel that was familiar with consumption of stiff paste assessed the colour, aroma, flavour, texture and overall acceptability of the product on a 9-point Hedonic scale (where 9 represented liked extremely and 1 represented disliked extremely).

Data analysis

Results obtained were subjected to analysis of variance (ANOVA) using SPSS 21. Sample means were compared and separated using Duncan multiple range test at 5 % probability level.

RESULTS

The proximate composition of the flour blends varied significantly ($p < 0.05$) (Table 2). The highest moisture (10.79 %), ash (1.67 %), crude fibre (5.70 %) and carbohydrate (68.53 %) contents were obtained in 100% water yam flour while 100% pigeon pea flour had the highest protein (20.98%) and fat (14.80%). The protein content of the blends which ranged from 5.19 % in 100 % WYF to 20.98 % in 100 % PPF, increased as the PPF increased in the blends. Inclusion of OBF and PPF reduced the ash and crude fibre contents of WYF.

Table 3 reveals that the mineral composition of the blends differed significantly ($p < 0.05$). The control sample (100% WYF) had the least calcium, magnesium and iron contents while the least values for potassium (1.01 mg/kg) and sodium (20.82 mg/kg) were observed in 17:17:67 (OBF:WYF:PPF) blend and 100% OBF, respectively. Flour blends obtained from 0:50:50 (OBF:WYF:PPF) and 17:67:17 (OBF:WYF:PPF) had the least values for phosphorus. Calcium, magnesium, sodium, phosphorus and iron contents were highest in 100 % PPF while the highest potassium content was obtained in 100 % OBF. Calcium content of the blends increased as the percentage inclusion of PPF increased, while the sodium increased with increase in OBF. The addition of OBF and PPF increased the Ca, Mg and Fe contents of WYF while the P content reduced.

There was a significant ($p < 0.05$) difference in the anti-nutritional content of the flour blends (Table 4). Phytate, tannin and trypsin inhibitor values ranged from 2.15 to 4.40 g/kg, 0.02 to 0.91 g/kg and 0.04 to 0.65 g/kg,

respectively. The concentration of phytate and trypsin inhibitors decreased as the percentage inclusion of PPF decreased. Inclusion of OBF and PPF increased the anti-nutrient composition of WYF.

Table 2: Proximate composition of ‘ogi’ bran-water yam-pigeon pea flour blends

OBF:WYF:PPF flour blends ratio	Moisture content (%)	Ash content (%)	Crude fibre content (%)	Protein content (%)	Fat content (%)	Carbohydrate content (%)
0:100:0	10.79 ^j	1.67 ^j	5.70 ^j	5.19 ^a	8.12 ^a	68.53 ⁱ
50:50:0	9.40 ^g	1.61 ⁱ	5.63 ⁱ	12.01 ^c	8.13 ^b	63.22 ^g
50:0:50	8.55 ^b	0.83 ^b	4.13 ^c	19.91 ⁱ	11.47 ^e	55.11 ^b
66.66:16.67:16.67	8.74 ^c	0.90 ^c	5.11 ^f	17.02 ^f	9.35 ^c	58.88 ^d
0:50:50	9.95 ^h	1.34 ^g	4.20 ^d	13.09 ^d	11.46 ^e	59.96 ^e
16.67:66.66:16.67	10.14 ⁱ	1.40 ^h	5.22 ^g	10.23 ^b	9.34 ^c	63.67 ^h
16.67:16.67:66.66	9.29 ^f	1.07 ^e	3.72 ^b	18.14 ^g	12.68 ^f	55.10 ^b
33:33:33	9.20 ^e	1.10 ^f	4.60 ^c	14.85 ^e	10.25 ^d	60.00 ^f
100:0:0	8.00 ^a	0.65 ^a	5.55 ^h	18.83 ^h	8.14 ^b	58.83 ^c
0:0:100	9.10 ^d	1.01 ^d	2.70 ^a	20.98 ^j	14.80 ^g	51.41 ^a

Means with superscripts within the columns were significantly different ($P < 0.05$)

OBF = ‘ogi’ bran flour; WYF = water yam flour; PPF = pigeonpea flour

Table 3: Mineral composition of ‘ogi’ bran-water yam-pigeon pea flour blends

OBF:WYF:PPF flour blends ratio	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	P (mg/kg)	Fe (mg/kg)
0:100:0	12.71 ^g	20.05 ^c	2.35 ^g	24.36 ^{bcd}	75.35 ^e	1.00 ^f
50:50:0	17.93 ^{bcd}	31.55 ^c	2.13 ^f	27.04 ^{abc}	1.32 ^c	3.96 ^e
50:0:50	20.02 ^{abc}	38.36 ^b	1.18 ^b	25.79 ^{bc}	1.59 ^b	6.43 ^{ab}
66.66:16.67:16.67	20.55 ^{ab}	37.84 ^b	1.77 ^{de}	28.28 ^{ab}	1.69 ^b	5.90 ^{abc}
0:50:50	13.79 ^{ef}	26.35 ^d	1.37 ^c	21.10 ^c	1.07 ^a	2.61 ^{ef}
16.67:66.66:16.67	14.33 ^{def}	26.33 ^d	1.86 ^e	24.59 ^{bcd}	1.07 ^a	2.94 ^e
16.67:16.67:66.66	16.41 ^{cdef}	33.62 ^c	1.01 ^a	23.34 ^{cd}	1.39 ^c	4.96 ^{bcd}
33:33:33	16.89 ^{bcde}	31.59 ^c	1.50 ^d	24.78 ^{bcd}	1.35 ^c	4.14 ^e
100:0:0	15.87 ^{def}	33.15 ^c	41.13 ^h	20.82 ^d	1.40 ^c	4.13 ^e
0:0:100	22.65 ^a	44.56 ^a	1.44 ^c	31.23 ^a	1.97 ^d	6.81 ^a

Means with superscripts within the columns were significantly different ($P < 0.05$)

OBF = ‘ogi’ bran flour; WYF = water yam flour; PPF = pigeonpea flour

Table 4: Anti-nutrient contents of 'ogi' bran-water yam-pigeon pea flour blends

OBF:WYF:PPF	Phytate (g/kg)	Tannin (g/kg)	Trypsin inhibitors (g/kg)
0:100:0	2.78 ^c	0.03 ^a	0.04 ^a
50:50:0	2.43 ^b	0.13 ^b	0.09 ^{ab}
50:0:50	3.23 ^e	0.12 ^b	0.11 ^{bc}
66.66:16.67:16.67	2.70 ^c	0.16 ^b	0.12 ^{bc}
0:50:50	3.60 ^f	0.26 ^c	0.04 ^a
16.67:66.66:16.67	3.01 ^d	0.51 ^d	0.05 ^a
16.67:16.67:66.66	3.81 ^g	0.56 ^d	0.63 ^d
33:33:33	3.13 ^{de}	0.91 ^e	0.08 ^{ab}
100:0:0	2.15 ^a	0.23 ^c	0.15 ^{bc}
0:0:100	4.40 ^h	0.02 ^a	0.65 ^d

Means with superscripts within the columns were significantly different (P < 0.05)

OBF = 'ogi' bran flour; WYF = water yam flour; PPF = pigeonpea flour

Table 5 shows that there was a significant (p<0.05) difference in the pH and colour values of the composite blends. It was observed that all the samples had pH less than 7. The L*, a* and b* values of the samples ranged from 79.46 - 82.53, 2.00 - 6.21 and 14.20 - 25.21, respectively. Except for 17:17:67, 33:33:33, 100:0:0 and 0:0:100 (OBF:WYF:PPF) blends, there was no significant (p>0.05) difference in the lightness of the other samples. The control sample (100 % WYF) distinctly exhibited the highest redness and lowest yellowness.

There were significant (p<0.05) differences in the functional properties of the flour blends (Table 6). The lowest and highest bulk density was recorded in 100% OBF and 100% PPF, respectively. The bulk density increased as percentage inclusion of PPF increased in the formulation. The wettability of the composite flours ranged from 32.00 s in 17:17:67 (OBF:WYF:PPF) blend to 96.00 s in 100% WYF while dispersibility was between 19.50 % in 0:50:50

(OBF:WYF:PPF) blend and 71.00% in 100% WYF. The swelling power of the blends was between 1.30% in 50:50:0 (OBF:WYF:PPF) blend and 7.80% in 100 % PPF. The addition of OBF and PPF resulted in decreased wettability, dispersibility and swelling power of WYF. The solubility index decreased as the percentage inclusion of OBF increased in the formulation. The water absorption capacity of the flour blends decreased as the percentage inclusion of WYF decreased. The least gelation capacity (15 - 20%) of the blends increased as the levels of PPF and OBF increased.

The stiff dough prepared from 100% water yam flour had the highest scores for all the sensory attributes (Table 7). On the other hand, the stiff dough prepared from blends of 50% OBF and 50 % PPF had the lowest scores for all the sensory attributes, except stickiness. The stiff dough prepared from blends of 50% OBF and 50% WYF was rated lowest in terms of stickiness.

Table 5: pH and colour attributes of ‘ogi’ bran-water yam-pigeon pea flour blends

OBF:WYF:PPF	pH	L*	a*	b*
0:100:0	5.75 ^e	82.28 ^{abc}	6.21 ^a	14.20 ^f
50:50:0	5.30 ^g	83.73 ^a	3.83 ^{cd}	18.31 ^{de}
50:0:50	5.82 ^d	83.40 ^a	2.23 ^a	22.11 ^c
66.66:16.67:16.67	5.14 ⁱ	82.53 ^{ab}	3.75 ^{cd}	23.20 ^{abc}
0:50:50	6.12 ^b	80.91 ^{cde}	4.30 ^{bcd}	18.62 ^d
16.67:66.66:16.67	5.59 ^f	82.16 ^{abc}	4.95 ^b	16.58 ^c
16.67:16.67:66.66	6.05 ^c	81.43 ^{bcd}	3.32 ^d	22.73 ^{bc}
33:33:33	5.75 ^e	80.43 ^{de}	4.44 ^{bc}	22.02 ^c
100:0:0	5.18 ^h	79.88 ^e	4.08 ^{bcd}	25.21 ^a
0:0:100	6.56 ^a	79.46 ^e	2.00 ^e	24.63 ^{ab}

Means with superscripts within the columns were significantly different (P < 0.05)

OBF = ‘ogi’ bran flour; WYF = water yam flour; PPF = pigeonpea flour

Table 6: Functional properties of ‘ogi’ bran-water yam-pigeon pea flour blends

OBF:WYF:PPF	Bulk density (g/mL)	Wettability (s)	Dispersibility (%)	Swelling power (%)	Solubility index (%)	WAC (%)	LGC (%)
0:100:0	0.63 ^d	96.00 ^a	71.00 ^a	7.33 ^f	7.61 ^f	2.62 ^c	15.00 ^c
50:50:0	0.60 ^e	58.50 ^c	60.50 ^d	1.30 ^a	1.02 ^a	2.75 ^b	17.00 ^b
50:0:50	0.63 ^d	54.00 ^d	50.00 ^e	1.77 ^b	1.18 ^b	3.36 ^a	19.00 ^a
66.66:16.67:16.67	0.62 ^d	77.50 ^b	64.50 ^c	7.54 ^c	1.21 ^b	1.91 ^f	19.00 ^a
0:50:50	0.70 ^c	41.50 ^e	19.50 ⁱ	5.53 ^d	8.99 ^g	1.87 ^f	16.00 ^{bc}
16.67:66.66:16.67	0.61 ^{de}	54.50 ^d	41.00 ^g	4.70 ^c	6.75 ^d	1.71 ^g	17.00 ^b
16.67:16.67:66.66	0.76 ^b	32.00 ^g	59.50 ^f	6.92 ^e	7.15 ^e	1.76 ^g	17.00 ^b
33:33:33	0.59 ^e	59.75 ^c	60.50 ^d	7.49 ^d	1.05 ^a	1.99 ^e	19.00 ^a
100:0:0	0.52 ^f	77.50 ^b	28.75 ^h	7.43 ^f	1.54 ^c	2.13 ^d	20.00 ^a
0:0:100	0.83 ^a	69.75 ^b	69.75 ^b	7.50 ^g	1.35 ^{bc}	1.63 ^h	17.80 ^a

Means in the superscripts in the column were significantly different (P < 0.05)

OBF = ‘ogi’ bran flour; WYF = water yam flour; PPF = pigeonpea flour; WAC = water absorption capacity; LGC = least gelation concentration

Table 7: Sensory properties of stiff dough prepared from ‘ogi’ bran-water yam-pigeonpea flour blends

OBF:WYF:PPF flour blends	Colour	Aroma	Texture	Stickiness	Taste	Overall Acceptability
0:100:0	6.85 ^a	6.20 ^a	6.30 ^a	6.05 ^a	6.00 ^a	6.37 ^a
50:50:0	4.70 ^d	4.70 ^{cd}	3.20 ^d	3.05 ^d	3.85 ^{de}	4.37 ^{cd}
50:0:50	4.65 ^d	3.95 ^d	3.15 ^d	3.50 ^{cd}	3.25 ^e	4.00 ^d
66.66:16.67:16.67	6.05 ^{abc}	5.55 ^{abc}	5.40 ^{abc}	5.30 ^{ab}	5.50 ^{ab}	5.70 ^{ab}
0:50:50	5.70 ^{bcd}	5.10 ^{abcd}	5.05 ^{bc}	4.60 ^{bc}	4.50 ^{bcd}	5.40 ^{abc}
16.67:66.66:16.67	5.55 ^{bcd}	4.55 ^{cd}	5.00 ^{bc}	4.65 ^{bc}	4.90 ^{abc}	5.40 ^{abc}
16.67:16.67:66.66	5.35 ^{cd}	4.95 ^{bcd}	4.50 ^c	4.65 ^{bc}	4.10 ^{cde}	5.10 ^{abcd}
33:33:33	6.50 ^{ab}	5.95 ^{ab}	5.85 ^{ab}	5.30 ^{ab}	5.30 ^{abc}	5.80 ^{ab}
100:0:0	4.80 ^d	4.55 ^{cd}	4.75 ^{bc}	4.15 ^{bcd}	4.10 ^{cde}	4.70 ^{bcd}
0:0:100	5.30 ^{cd}	4.90 ^{bcd}	4.55 ^c	3.90 ^{cd}	4.55 ^{bcd}	4.70 ^{bcd}

Means in the superscripts in the column were significantly different ($P < 0.05$)

OBF = ‘ogi’ bran flour; WYF = water yam flour; PPF = pigeonpea flour

DISCUSSION

Moisture content was significantly ($p < 0.05$) different in the samples; similar effect was observed in ash, protein and carbohydrate contents. The low moisture content (8.00 to 10.31 %) of the blends signifies good storability of the blends because milled food products with moisture content less than 13% are stable from moisture-dependent deterioration (Potter and Hotchkiss, 1995). Legumes have been reported to improve the protein content of starch-based foods (Olaoye *et al.*, 2006; Odeny, 2007; Abioye *et al.*, 2011). The protein contents of the flour blends, except that of 100 % WYF, were within the recommended intake level of 10 – 15 % specified by the Joint WHO/FAO Consultation (2003). This implies that the flour blends could help to alleviate the problem of protein malnutrition in developing countries. The increase in the crude fibre of the composite flours as the content of OBF increased may indicate the possible richness of OBF in dietary fibre and its potential to reduce incidence of cancer, coronary heart disease and serum cholesterol

(Mallillin *et al.*, 2008; Okafor and Ugwu, 2014).

The trend observed in the mineral composition of the flour blends revealed that the inclusion of OBF and PPF improved the mineral composition of WYF. The low content of these anti-nutrients observed in this study shows that the processing method employed significantly reduced its concentration. Thus, it is expected digestibility of protein and absorption of minerals such as calcium, iron and zinc will not be hindered.

The result for pH indicates that the entire samples were slightly acidic in nature and it may be as a result of the fermentation process involved in the preparation of OBF and WYF. The value obtained for pH was similar to the finding of Adelekan and Oyewole (2010) on production of ‘ogi’ from germinated sorghum with soybean. The acidic nature of the flour blends may prolong their shelf life. Colour is an important attribute in food product

identification and acceptability. According to Szabo *et al.* (2016) the resulting L* value signifies the lightness of the flour blends while the positive value for a* and b* shows the level of redness and yellowness, respectively. The lower the L* value the darker the food product (Kumar *et al.*, 2012). The positive a* and b* values exhibited by the blends indicated that the products were in the red and yellow colour zones. Colour is the first property that consumers consider in food products (Kumar *et al.*, 2012).

All the composite flours had relatively high bulk density, an indication of high compactness of the starch molecules (Falade and Olugbuyi, 2010). Wettability is important in reconstitution in water as it relates to the presence of soluble molecules. Dispersibility is a measure of the degree to which flour or flour blends reconstitute in water; the higher the dispersibility, the better the flour reconstitution in water (Adebowale *et al.*, 2011). The trend observed in the dispersibility and swelling power of the blends may indicate that the addition of OBF and PPF reduced the capacity of WYF to both produce a smooth dough and as well as imbibe water (Adebowale *et al.*, 2011). The variability in the swelling power of the blends may be due to differences in their moisture fat, carbohydrate and protein constituents (Oppong *et al.*, 2015). Solubility index is a measure of dextrinization and it is affected by the amount of lipid in the food matrix (Oppong *et al.*, 2015). Water absorption capacity measures the ability of a sample to absorb water. A sample's ability to absorb water is dependent on its protein content (Ayo-Omogie and Ogunsakin, 2013). The water absorption capacity of the flour blends which decreased as the percentage inclusion of WYF decreased may be due to the fact

that the ability of a flour sample to absorb water has a significant correlation with its starch content (Ade-Omowaye *et al.*, 2008; Ayo-Omogie and Ogunsakin, 2013).

Least gelation capacity determines the minimum quantity of flour needed to form a gel in a measured volume of water. It usually depends on the relative ratios of structural constituents such as protein, carbohydrates and lipids (Abbey and Ibeh, 1998). The least gelation capacity of the blends which increased as the levels of PPF and OBF increased may imply that more flour will be needed to form stiff paste (Adebowale *et al.*, 2005).

The trend observed in the sensory properties of the stiff dough indicates that the blend containing 50% OBF and 50% PPF was the least preferred in terms of aroma, texture, stickiness, taste and overall acceptability while 100% WYF, with the highest wettability and dispersibility, was the most preferred in terms of in terms of aroma, texture, stickiness, taste and overall acceptability. The inclusion of 'ogi' bran and pigeon pea reduced the sensory attributes of stiff dough prepared with water yam. This may be due to the familiarity of consumers to stiff dough prepared from water yam.

CONCLUSION

The study has shown that the combination of 'ogi' bran, water yam and pigeon pea flours is a potential good source of crude fibre and other important minerals such as magnesium and iron. Values for bulk density and least gelation capacity increased as PPF increased while increase in wettability and dispersibility was observed as inclusion of WYF increased. Stiff dough prepared from 100% WYF though had highest overall acceptability, was not significantly ($p < 0.05$)

different from the ones obtained from 66.66:16.67:16.67, 0:50:50, 16.67:66.66:16.67, 16.67:16.67:66.66 and 33.33:33.33:33.33 (OBF:WYF:PPF).

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