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Production and Quality Evaluation of Ogi Produced from Fermented Maize and Horse Eye Bean (*Mucuna urens*)

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Abstract: In developing countries, particularly sub-Saharan Africa, infant complementary foods are grossly inadequate, the enrichment of maize with horse eye beans is a veritable approach for combating the effects of protein malnutrition. Yellow maize variety and horse eye bean were processed into flour, mixed in the ratios 95:5, 90:10, 85:15 and 100% maize flour and proximate, functional, pasting, antinutritional and sensory properties were evaluated using standard methods. Results of Proximate analysis, functional analysis, pasting characteristics, anti-nutritional analysis and sensory evaluation showed protein, crude fibre and ash increase with an increase in ratio of horse eye bean flour addition. Proximate analysis performed on the samples showed that sample (85:15) has the highest protein content of (12.37%), fat content, (2.77%) and ash content (0.71%). The control sample (100% maize flour) had a high carbohydrates content of (77.32%) and moisture content range from 4.18 to 4.61%. The functional properties of all samples had almost the same level of bulk density (0.69%). A significant difference was observed in water absorption capacity of the samples (1.5-3.33%) and likewise swelling capacity. Pasting characteristic (peak viscosity, final viscosity and holding strength) also decreased significantly as proportion of horse eye bean flour increases above 10%. The setback value and breakdown viscosity of maize flour containing zero or 5% horse eye bean flour were significantly lower than those containing 10 and 15% horse eye bean flour. Apart from producing a nutritionally balanced amala meal, 10% fortification was more stable against retrogradation and was assessed to be more acceptable in terms of key quality index (texture and colour). Therefore the result obtained revealed that the proximate parameters of the samples increases as the horse eye beans added increase, which confirm the reality of the enrichment. However, in terms of overall acceptability the blend ratio of 95:5% horse eye bean was the most the acceptable to the panelist <0.05. Apart from adding value and varieties to Ogi meal due to its textural improvement, fortifying maize flour with horse eye bean flour at 5% level would also reduce the problem of food security especially among children in the sub-Sahara region of Africa where malnutrition due to protein deficiency is common and also the utilization of horse eye bean.

Key words: Maize, horse eye bean, Ogi, pasting, functional and sensory properties

INTRODUCTION

The current food and nutrition crisis in most parts of the world, particularly in Sub-Saharan Africa, is the result of the inability of most countries in this region either to produce, purchase or stock enough food to satisfy the rising demand, especially in the urban centres. When food supplies cannot meet the demand, the result is hunger, hence nutritional deficiency. The problem of protein malnutrition in humans has been recognized as one of the major nutritional deficiencies. Although animal proteins are superior to plant proteins, their ratio in diets, especially in developing countries, is not likely to change in the immediate future due to inadequate supply and high unit cost (Lopez-Bellido and Fuentes, 1986).

In developing countries, particularly sub-Saharan Africa, breakfast meals for both adults and infants are based on local staple diet made from cereals, legumes, roots and cassava and potatoes tubers. However, results from

previous studies note that most cereals are limited in essential amino acids such as threonine and tryptophan even though rich in lysine (Anglani, 1998; Perez-Consessa *et al.*, 2002; Mensa-Wilmot *et al.*, 2001; Nnam, 2001; Onweluzo and Nnamuchi, 2009), while most oil seeds and legumes are rich in essential amino acid particularly the Sulphur amino acids (Radha *et al.*, 2007; Kanu *et al.*, 2007a, b). Thus a combination of such food stuffs will improve the nutritional value of the resulting blend that will make it better compared to the individual components alone (Mensa-Wilmot *et al.*, 2001). In Nigeria, West Africa for example, an extensive work has been done in an effort to formulate various breakfast and infant cereal meals by combining the available local cereals and legumes (Mensa-Wilmot *et al.*, 2001; Egounlety, 2002; Kanu *et al.*, 2007c). A cereal is staple food of people in the tropics of most African countries and some other part of the world. Cereals belong to the grass family graminea that provide 75% of people

calories intakes. Cereals include wheat, rice, rye, maize, sorghum, millet. Cereals are taken in large quantities when compared to other food crop and have an important common features and this form the basis for milling and processing operations. Legumes is a very wide varieties, they can be grouped into two and to their importance as food sources. We have pulses which include peas, cowpeas, black eye, chick pea, horse eye beans and the oil seed which consist of legumes used primarily for their oil content that may be extracted by pressing or solvent extractor which include groundnut or peanut; soybeans in some cases, their residue or cake is high in protein. Legumes contain about 20-25% protein. The suitability of cereals, oil seed and legumes blend meals for human consumption has been extensively reviewed (Kulkarni *et al.*, 1991; Radha *et al.*, 2007) and many countries have reported success in those formulations (Anglani, 1998; Kanu *et al.*, 2007c). In Nigeria, however, with all the attempts made, no appropriate blend had ever been formulated that meets the nutritional requirements of the old age. Thus, this research is an attempt to formulate a cereal-based porridge meal with additional constituents such as horse eye bean and sugar in various proportions for especially adults. Cereals, maize is both locally produced and abundantly available. They have been reported for their suitability in food formulations (Kulkarni *et al.*, 1991; Choi and Sohn, 1997). Composite flours have their properties that enhance their wide utilization which include water and oil absorption capacity, foaming capacity foam stability, bulk density, gelation capacity, emulsion capacity (Adeyemi, 1989; Abbey and Ibeh, 1988). Incorporation of sweet potato flour into wheat flour for bakery goods production is expected to produce effect in both the functional properties and pasting characteristics of the blended samples. Several studies have indicated the possibility of incorporating hulless barley, soya beans, sorghum, cowpea flour into wheat flour at various levels and the rheological and baking properties have been reported (Kinsella, 1979; Sathe and Salekhe, 1981). Horse eye bean has been extensively investigated and reported to possess many health benefits to humans particularly for its quality protein content (Abou-Gharbia *et al.*, 2000). As far as our knowledge is concerned based on literature review, no attempts have ever been made to combine the above food stuffs to obtain a blend that could be used as a cereal-based porridge meal for the aged. Thus, the objective of this work is to formulate cereal-based blend porridges as meals for the aged and compare and report their nutritional composition while enhancing the utilization of horse eye beans which is currently being under-utilized.

MATERIALS AND METHODS

Materials: Yellow maize and *Mucuna urens* were all purchased from a local market at Mile 2 in Lagos State.

Sample Preparation of maize flour: The fermented maize flour was produced by soaking sorghum grains in water for 48 h. The softened kernel was milled and sieved to remove the germs and hulls. Water was added to the product, which is almost pure starch and this mixture is allowed to ferment anaerobically for 72 h. The fermented meal was then pressed to produce the fermented maize cake. The cake was then dried in oven at 60°C and milled using locally fabricated attrition mill to obtain sieve size of 0.5 µm mesh size to produce the fermented maize flour.

Processing of horse eye bean sample: The horse eye bean (*Mucuna urens*) was cracked, soaked for 24 h and then dehulled and soaked again for 24 h to reduce the antinutritional factors present in the bean. The soaked bean was then drained and cooked using a pressure cooker at 100°C for 30 min. The cooked horse eye bean was oven dried at 60°C for 48 h and then milled using locally fabricated attrition mill to obtain sieve size of 0.5 µm mesh size to produce flour of the same sieve size (0.5 µm) and stored in labeled plastic containers.

Preparation of the blends: Different samples were prepared by combining 100% maize flour, 95, 90 and 85% fermented maize flour with 0, 5, 10 and 15% respectively of horse eye bean flour (Table 1).

Proximate analysis

Moisture content determination: Five grams of sample was weighed into a Petri-dish of known weight. The weighed sample was put into an oven pre-set at 110°C for 3 h. The sample was removed and cooled in a dessicator to room temperature and the weight was determined after which it was returned into the oven at 110°C for 30 min until constant weight was obtained: AOAC (2005).

Ash content determination: Five grams of sample was weighed into a previously ignited and cooled silica dish. The dish was ignited gently first and then at 600°C for 3 h in a muffle furnace. The dish and its content were cooled in a dessicator and reweighed; the weight of the residue was recorded as ash content.

Crude fat determination: Crude fat was determined by the method of AOAC (2005). This was determined using a Soxtec System HT2 fat extractor. Crude fat was extracted from the sample with hexane and the solvent evaporated off to get the fat. The difference between the initial and final weight of the extraction cup was recorded as the crude fat content.

Crude protein determination: Crude protein was determined by Kjeldahl method using Kjeltac TM model 2300, as described in Foss Analytical manual, AB, (2003). The method involved digestion of the sample at

420°C for 1 h to liberate the organically bound nitrogen in the form of ammonium sulphate. The ammonia in the digest ammonium sulphate was then distilled off into a boric and receiver solution and then titrated with standard hydrochloric acid. A conversion factor of 6.25 was used to convert from total nitrogen to percentage crude protein (AOAC, 2005).

Carbohydrate content determination: The carbohydrate content was estimated by subtracting the sum of percentage of moisture, fat, protein and ash contents from 100% according to AOAC (1995).

Functional properties

Bulk density (BD): BD was determined using the method described by Wang and Kinsella (1976) with slight modifications. 10 g of the test materials were placed in a 25 mL graduated cylinder and packed by gentle tapping the cylinder on the bench top ten times from a height of 5-8 cm. The final volume of the test material was recorded and expressed as g/mL.

Water absorption capacity: (WAC) was determined by the method of Cegla *et al.* (1977) with slight modifications. 10 g of each formulation were weighed in a 100 mL beaker. A known volume (5 mL) of water was pipetted into the beaker, carefully stirred and allowed to equilibrate for one hour at room temperature (23-25°C). After complete water absorption, the sample was further treated with 0.01 mL water portion at 10 min interval before visual observation. The volume that gave a complete absorption of water (no visible free water) was recorded. Water absorption capacity was calculated as the ratio of maximum amount of water in grams absorbed by 100 g dry material.

Determination of pasting properties: Pasting properties were determined with a Rapid Visco Analyzer (RVA) (Newport Scientific RVA Super 3). An aliquot 3 g of sample was weighed in a vessel; 25 mL of distilled water was dispensed into a new test canister. The sample was then transferred into the water surface in the canister. The paddle was placed into the canister and the blade vigorously jogged through the sample up and down ten times. The test proceeded and terminated automatically. The slurry was heated from 50 to 95°C and cools back to 50°C within 12 min, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown value, pasting temperature and time to reach peak viscosity.

Determination of antinutritional factors: Concentrations of some common anti-nutritional factors present in the horse eye bean were determined. These included total

oxalate (Dye, 1956), tannins (Burns, 1971) and phytic acid (Wheeler and Ferral, 1971). Cyanogenic glycoside was estimated by determining the amount of HCN released on hydrolysis through the alkaline titration method (AOAC, 2005).

Sensory evaluation: Porridges were prepared from each of the composite flour. One hundred grams of each flour was homogenized with 500 mL deionized water. The slurry was heated slowly with constant stirring for 15 min. One teaspoon of sugar was added to each sample. The porridges were kept separately in thermos flask for sensory evaluation with 20 untrained panelists drawn from Yoruba ethnic group among the staff and students of Department of Food Technology, Yaba College of Technology. They evaluated the samples using a nine point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked) (Watts *et al.*, 1989). The five porridges were coded appropriately in the hedonic scale. Each judge was given six white plastic cups and teaspoon for use in the sensory evaluation. The judges were provided with clean water to rinse their mouth in between testing of the porridges to avoid carry over effect. Each panelist evaluated the porridges for color, flavour, texture, taste and overall acceptability.

Data analysis: Proximate analysis was carried out in three triplicates while pasting properties was in duplicate. The data were subjected to Analysis of Variance (ANOVA) ($p < 0.05$). Means with significant differences were separated by Turkey test using SPSS 11.0 software.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition is shown in Table 2. The proximate analysis showed that all the samples were within the normal moisture contents of dried food (flour blends). According to these results there are significant differences ($p < 0.05$) in the moisture content of the four formulations. The moisture content ranged between 4.30 ± 0.01 and $4.01 \pm 0.01\%$. The low moisture observed for the five formulations is a good indicator of their potential to have longer shelf life. This is in line with the findings of Vincent (2002). It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content. For this reason, a water content of 10% is generally specified for flours and other related products. It should be pointed out that when these products are allowed to equilibrate for periods of more than one week at 60% relative humidity and at room temperature (25 to 27°C), moisture content might increase. The moisture content of the sample range from 4.18-4.70% which is not above acceptable value for flour and this came about as a result of dehydration processes involved. And this

Table 1: Blends of maize flour and horse eye bean flour

Sample	Maize flour	Horse eye bean flour
100% Maize flour	100%	0
95%: 5% horse eye bean	95	5
90%: 10% horse eye bean	90	10
85%: 15% horse eye bean	85	15

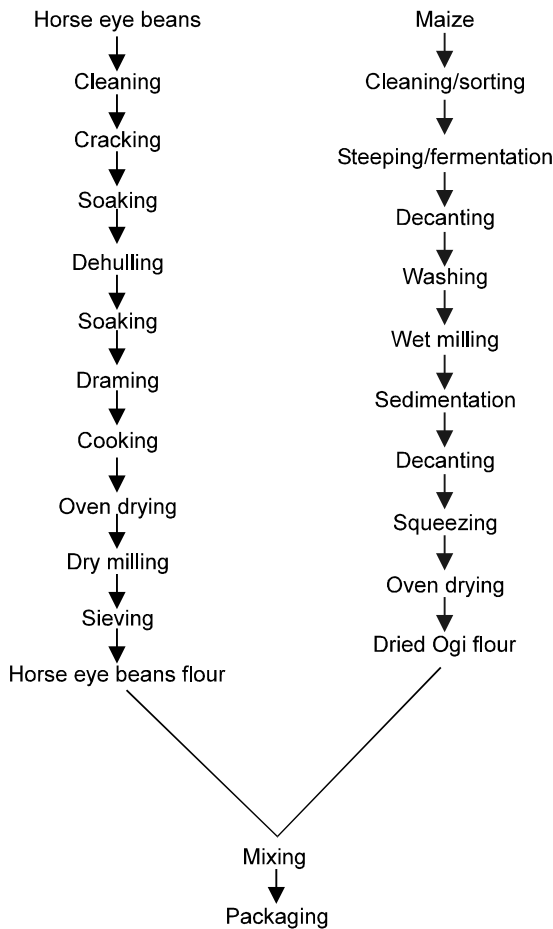


Fig. 1: Flow chart for the production of "Ogi" produced from the horse eye beans and maize (Sridhar and Bhatt, 2000)

would enhance the shelf stability of the product (Ihekoronye and Ngoddy, 1985). The result of proximate analysis shows that there is an increase in the parameter of the flour as the level of the horse eye beans increases, while the carbohydrate content decreases with an increase in the level of substitution of the product. In terms of protein content of the sample (85:15) add a significantly ($p < 0.05$) high protein content of 12.37% while the same 100% sample had the lowest content of 11.18%. The significant improvement of the protein content of the sample is not unexpected since horse eye bean flour is rich source of protein. The total

carbohydrate was significantly higher ($p < 0.05$) as sample 100% maize flour (77.32%) compared to other samples, this may be due to fact that its 100% maize flour. The ash content ranged from 0.05% to 0.11%. These values are similar to the values reported from the production of legumes fortified weaning food (Egounlety, 2002) but lower than reported results of Kanu *et al.* (2009) from production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults. The ash contents were significantly present ($p < 0.05$) in all the samples. Sample 85:15 had the highest content of 0.71%, followed by 90:10 with a value of 0.65% while 100% sample and 95:5 sample had the same ash content value of 0.45%. This may be due to high organic content of the horse eye bean, since ash content represent the total mineral content in food and thus serve as variable tools for nutritional evaluation. The moisture content of the sample ranges from 4.18 to 4.70% which is not above acceptable value for flour and this came about as a result of dehydration processes involved and this would enhance the shelf stability of the product. Both (95:5) and (85:15) were significantly present in varying amount of lipids of 2.34 and 2.77%, respectively. These findings were in agreement with the work of (Kolapo and Sanni, 2005). The carbohydrate content decreased with increase proportion of the soy flour supporting the claims of (Jimoh and Olatidoye, 2009; Akpapunam, *et al.*, 1997). Other research workers have reported similar findings (Kure *et al.*, 1998; Edema *et al.*, 2005; Onyeka and Dibia, 2002; Plahar *et al.*, 2003).

He result of the study was significantly lower than the reported results of Egounlety (2002) for the nutritive value of protein-energy legume-fortified weaning for 'Ogi' and reported results of Kanu *et al.* (2009) who also studied production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults and the result reported for Binnimix (Kanu *et al.*, 2007c). Ashaye *et al.* (2001) reported an increase in protein content (7.28%) and ash (3.58%) when yam flour was substituted with 40% cowpea flour while Achi (1999) reported an increase in protein content from 3.5% in the control (yam flour) to 19.7% for yam flour fortified with 40% soybeans flour. Carbohydrate content varied and decreased with addition of walnut flour. This was in agreement with the findings of Jimoh and Olatidoye (2009) who reported a decrease in carbohydrate content with increase in soybean flour fortification.

Functional properties: The bulk density of the sample was notice to have almost the same value of % i.e., (0.69%) except sample HER that had (0.67%). Bulk density gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility

Table 2: Proximate composition of flour produced from blend of maize and horse eye bean

Samples	Carbohydrate (%)	Protein (%)	Lipids (%)	Moisture (%)	Ash (%)	Crude fibre (%)
MF:HBF						
100:0	77.32±0.11 ^a	10.18±0.08 ^b	1.89±0.06 ^c	4.18±0.07 ^c	0.45±0.01 ^c	2.48 ^c
95:5	72.04±0.22 ^d	11.10±0.05 ^c	2.34±0.05 ^b	4.61±0.02 ^b	0.45±0.02 ^c	7.48 ^b
90:10	72.75±0.27 ^c	12.21±0.03 ^{ab}	2.76±0.04 ^a	4.70±0.02 ^a	0.65±0.01 ^b	7.69 ^b
85:15	71.83±0.32 ^b	12.37±0.10 ^a	2.77±0.01 ^a	4.43±0.01 ^b	0.71±0.01 ^a	9.68 ^a

Mean values with different letter within the same column are significantly different (p>0.05)

Table 3: Functional properties of blends of fermented maize and horse eye bean flour

Parameters	WAC	Bulk density	Swelling capacity
85% MF: 15% HBF	2.46±0.01	0.51±0.01	1.84±0.01
90% MF: 10% HBF	2.71±0.01	0.51±0.01	1.86±0.01
95% MF: 5% HBF	2.35±0.02	0.47±0.01	1.86±0.01
100% MF	2.67±0.02	0.54±0.01	1.92±0.01

MF: Maize flour, HBF: Horse eye bean flour

WAC: Water absorption capacity

and reduction of paste thickness which is an important factor in convalescent child feeding (Padmashree *et al.*, 1987). The bulk density is related to particle size reduction which is evidence on the milling of the product. Also bulk density is an indication of porosity of a product which influence packaging design and could be used to determine the type of packaging material required (Iwe and Onadipe, 2001). There was an increase in the level of water absorption capacity. Sample FAV had high water absorption capacity (3.54%), HER (3.33%) TEM (1.44%). The increase in water absorption capacity implies high digestibility of the starch. Its characteristics represent the ability of the product to associate with water under condition where it is limiting in order to improve handling (Miami, 1993). Water binding capacity is a useful indication of whether flour or isolates can be incorporated into aqueous food formulations especially those involving dough handling (Okerie and Bello, 1988; Miami, 1993). The higher water absorption capacity results obtained suggest that *Mucuna* bean protein isolate flours could be useful in food systems such as bakery products which require hydration to improve handling characteristics. Sample were significant different (p<0.05) in swelling capacity sample. FAV had the high value of swelling capacity. These properties agreed with fact that horse eye bean flour is a good thickener that has been earlier reported by Adebowale *et al.* (2005).

Pasting properties: The pasting properties are shown in Table 3. Pasting characteristics is largely depended on amylase to amylopectin ratio of the starch (Sanni and Akinlua, 1996). This indicates that the carbohydrate components of the flour samples will not breakdown until it is properly cooked and peak viscosity was reported to be important to the user in order to obtain a useable starch paste (Adeyemi, 1989). When starch-based foods are heated in an aqueous environment, they undergo a series of changes known

as gelatinization and pasting. These are two of the most important properties that influence quality and aesthetic considerations in the food industry, since they affect texture and digestibility as well as the end use of starchy foods (Adebowale *et al.*, 2005). The pasting properties are important as it is used in predicting the behaviour of porridge during and after cooking. The peak viscosity value ranged from 380.5 to 235.5RVU. The highest value was recorded in the unsubstituted maize flour (control) while the lowest value was recorded in the sample (85:15). Peak viscosity is the ability of starch to swell freely before their physical breakdown (Sanni *et al.*, 2004). High peak viscosity is an indication of high starch content (Osungbaro, 1990). It is also related to the water binding capacity of starch (Adebowale *et al.*, 2005). Peak viscosity is the maximum viscosity attained during or soon after the heating portion of the test in RVU. It also provides an indication of the viscous load likely to be encountered during mixing. The trough value ranged from 354.5 to 232.5 in unsubstituted maize flour and substituted maize flour, respectively. The trough is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling. The breakdown viscosity value is an index of the stability of starch (Fernande and Berry, 1989). Breakdown is a measure of susceptibility of cooked starch granules to disintegration and has been reported by Beta *et al.* (2000) to affect the stability of the flour products. A low breakdown value suggests that they are more stable under hot condition. This is as a result of lower concentration of starch in the sample and it is in agreement with (Ayenor, 1985) who observed that viscosity correlated with concentration of starch-in given food material. Breakdown set point ranged from 25.5 to 63.0 while final viscosity value ranged from 328.4 to 163.5RVU. Set back value ranged from 131 to 213RVU. Peak time value ranged from 5.7 to 6.3 min. Pasting temperature value ranged from 71.65 to 55.55°C. The pasting temperature of the porridge is lower than the boiling temperature; hence the porridge can form a paste in hot water below boiling point. This means at a commercial level, there is a remarkable cost saving. Viscosity also depends on the shape and swelling power of the granule and amylopectin granules interaction (Ring *et al.*, 1987). Peak viscosity is the maximum viscosity attained during or soon after the heating portion of the test in RVU. Peak viscosity

Table 4A: Pasting properties

Sample	Peak viscosity	Trough RVA	Breakdown value	Final viscosity	Setback value	Peak time	Pasting Temperature
MF:HBF							
100%MF:0%HBF	380.5 ^a	354.5 ^a	25.5 ^a	328.4 ^a	131 ^a	5.7 ^c	71.65 ^a
95%MF:5%HBF	314.2 ^b	299.5 ^b	44.5 ^b	284.5 ^b	165 ^b	5.8 ^b	66.98 ^b
90%MF:10%HBF	283.4 ^c	273.6 ^c	59.5 ^b	235.5 ^c	182 ^b	5.8 ^b	65.25 ^b
85%MF:15%HBF	235.5 ^d	232.5 ^d	63.0 ^a	163.5 ^d	213 ^a	6.3 ^a	55.55 ^c

MF: Maize flour, HBF: Horse eye bean flour

Table 4B: Antinutritional composition of maize and horse eye bean blends

Sample	Tannin (mg/100 g)	Oxalate (mg/100 g)	HCN (mg/100 g)	Phytic acid (mg/100 g)
100%MF	0.92±0.002	0.20±0.02	1.05±0.02	2.11±0.02
95%:5%HBF	5.15±0.002	4.03±0.00	2.52±0.06	6.10±0.00
90%:10%HBF	6.17±0.001	6.05±0.02	3.25±0.04	8.13±0.00
85%:15%HBF	8.70±0.005	7.10±0.07	4.08±0.05	10.19±0.00

MF: Maize flour HBF: Horse eye bean flour

Table 5: Mean sensory scores of Ogi from maize and horse eye bean flour blends

Parameter	Colour	Mouthfeel	Aroma	Taste	Acceptability
100% MF	2.6 ^a	2.8 ^a	2.8 ^a	2.9 ^a	3.3 ^a
95% MF: 5% Horse eye bean flour	2.5 ^a	2.7 ^a	2.6 ^b	2.7 ^a	2.8 ^b
90% MF:10% Horse eye bean flour	2.3 ^b	2.4 ^b	2.5 ^b	2.6 ^b	2.5 ^c
85% MF:15% Horse eye bean flour	2.0 ^c	2.2 ^c	2.1 ^c	2.3 ^c	2.3 ^c

Mean with different letters are statistically different (p = 0.05) according to Duncan's multiple range test

indicates the water binding capacity of the starch or mixture and it occurs at the equilibrium point between swelling causing an increase in viscosity rupture and alignment causing its decrease. The peak viscosity indicates the water-binding capacity of the flour samples and is important to the user in order to obtain a useable starch paste (Adeyemi, 1989). Breakdown is peak viscosity minus trough viscosity in RVU. Final viscosity is the most commonly used parameter to define the quality of a particular starch-based sample, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990). Final viscosity indicates the ability of the material to form a viscous paste or gel after cooking and cooling. Also, the final viscosity (328.4 RVU) value of 100% maize sample indicated the ability to form a firm, viscoelastic paste or gel after cooking and cooling owing to re-association of starch molecules (Newport Scientific, 1998). This was in agreement with the finding of Jimoh and Olatidoye (2009) who reported high values for yam flour and decrease in the soybean fortified yam flour samples. Abiodun *et al.* (2010) also reported an increase in peak viscosity of trifoliolate yam flour with increase in cassava starch substitution. Peak time was also higher for starch samples in this work and ranged from 5.7 to 6.3. The setback involves the retrogradation of the starch molecules particularly the amylose component. The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the flour (Adeyemi and Idowu, 1990). Setback has been correlated with texture of various products and also, an index of the tendency of the cooked flour to harden on cooling due to amylose retrogradation (Adeyemi, 1989). High setback is also associated with syneresis, or weeping, during freeze-

thaw cycles for example and substituted starches are commonly used where this presents a quality defect. There is a relationship between amylose content and set back; high amylose indicates high leaching hence high setback. The rate of starch breakdown depends on the nature of the materials, the temperature and the degree of mixing and shear applied to the mixture (Newport Scientific, 1998). The ability of a mixture to withstand heating and shear stress that is usually encountered during processing is an important factor for many processes especially those requiring stable paste and low retrogradation/seneresis. High holding strength exhibited by sample unfortified sample (control) showed that the flour could withstand high heat treatment during processing than the substituted flour sample. Bhattacharya *et al.* (1999) indicated that high holding strength generally represents low cooking loss and superior eating quality. The substituted flour samples had lower breakdown values which were not significantly different (p>0.05) from each other. Samples with low breakdown values indicated high stability (Beta *et al.*, 2000). Therefore, substituted flour samples were more stable than the maize flour alone. Pasting temperature is a measure of the minimum temperature required to cook a given food sample and also gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable viscosity is measured and an index characterized by initial change due to the swelling of starch, it can have implications for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998). Pasting temperature has been reported to relate to water binding capacity, a higher pasting temperature implies higher water binding capacity property of starch due to high degree of association between starch granules (Kulkarni *et al.*, 1991).

Anti-nutritional factor: The results of the antinutritional content the porridges produce from composite flour are shown in Table 4B. The tannin content level of the samples showed that the sample (85% maize: 15% horse eye bean) has the highest level of (8.70±0.005 mg/100 g). But compared the level of tannin in the unprocessed horse eye bean as cited by Umoren *et al.* (2007) which is 468 mg/100 g, this level is relatively low and may constitute little significance. Tannins are known to bind to proteins, including digestive enzymes thereby causing decrease in the protein and dry matter digestibility (Rao, 1994). The level of oxalate was found to vary between 0.20±0.02, 4.03±0.00, 6.05±0.02 and 7.10±0.07 for samples 100% MF, 95%:5% HBF, 90%:10% HBF and 85%:15% HBF, respectively. The lethal dose for concentration of hydrogen cyanide in food materials is 50-60 mg as reported by Burns (1971). The value of hydrogen cyanide in the samples are 1.05±0.02, 2.52±0.06, 3.25±0.04 and 4.08±0.05 which increase in with the increase in the level of substitution with horse eye bean. However, these values obtained were lower than the lethal dose for consumption; this indicated that the respective samples are at a safe level with regard to hydrogen cyanide level. These reports suggest that tannic and phytic acids are heat-stable. The complex nature of tannin structure and the strong electrostatic force existing between the contiguous phosphate radicals within the phytate structure will affect the extent to which tannins and phytate could be affected by heat processing (Bate-Smith, 1973; O'Dell and de Boland, 1976).

Sensory evaluation: Table 5 presents the sensory scores associated with porridges made from the composite flours and the control. The mean sensory scores of the control porridge and those of the composite flour differed significantly (≤ 0.05) in colour, taste, aroma, mouthfeel and general acceptability. The appearance of the porridges from sample blends was moderately liked by mothers. However, the control was liked moderately. Colour is an important sensory attribute of any food because of its influence on acceptability. It also shows the suitable raw material used for the preparation, provides information about the formation and quality of the product. The taste, flavour, texture and general acceptability all ranged between like slightly and dislike moderately. However, the porridges from all the blends differed significantly (≤ 0.05) with the control. Sample blend (95:5) was most generally accepted among the samples. The variation in the proportion of the horse eye bean flour resulted in the difference (> 0.05) in the sensory attributes measured. The control had more acceptability in all the sensory attributes studied. This could be because the familiarity in taste, flavour and colour. This food formulation will provide the required protein and energy level that will

provide basic nutrient for the day's work and eventually ameliorate the problem of malnutrition in the rural areas of Nigeria (Bilsborough, 2006). In conclusion, it was observed that supplementation beyond (10% of horse eye beans flour) affected the palatability, hence the organoleptic quality of the product.

Conclusion: The findings of this research revealed that sample which was blended at the ratio 80:20 bambara nut flour and sweet potato flour was nutritionally superior when compared with other samples and would produce a more nutritionally balanced and acceptable products which will be cheaper and readily available. Hence, it can be concluded that the addition of sweet potato flour to germinated bambara-nut flour enhanced the nutritional composition of the steamed stiff paste. Being cheaper and readily available, bambara-nut fortification of sweet potato flour would have little or no effect on the price of the product. Further studies are necessary to determine the shelf life of the product and economics of large scale production.

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