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Full Length Research Paper

Proximate composition and functional properties of wheat, sweet potato and hamburger bean flour blends

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The study assessed the proximate composition and functional properties of composite flour produced from fermented brown hamburger bean seed (*Mucuna sloanei*) , sweet potato (*Ipomoea batatas*) and wheat flour. Five blends of wheat flour (WF), sweet potato(SPF) and hamburger bean seed flour(HBF) were prepared using the following ratio WF:SPF:HBF - Sample B (90:5:5), Sample C (80:10:10), Sample D (70:15:15), Sample E (60:20:20) and 100% wheat flour was used as control (Sample A). The result of proximate analysis showed that the sample A had the highest moisture content and decreased as sweet potato and hamburger bean flours were added indicating good storability for the flour. The incorporation of hamburger bean seed and sweet potato into the wheat flour increased the crude protein and fat content of the blends from 12.51-15.15% and 2.59-3.79% respectively. The incorporation of hamburger bean seed and sweet potato flour into wheat flour significantly (p< 0.05) decreased the carbohydrate content of the wheat flour and there was significant increase in (p<0.05) in the ash content signifying increase in minerals of the flour blends. The functional properties of the composite flour also significantly improved. Thus the composite flour is a potential raw material in food systems for household use and commercial activities.

Keywords: Composite flour, Functional properties, Hamburger bean flour, Proximate composition, Sweet potato flour

INTRODUCTION

Flour is the major ingredient in bakery goods production which constitutes a staple in the diet of many countries including Africa. The flour for the bakery products is usually from wheat but the harsh climatic conditions in the tropical regions is not conducive for the growth of wheat, thus these countries have to bear the high financial burden of importing wheat with all its limitations in essential amino acids namely lysine and tryptophan. For these reasons, FOA and the developing countries became interested in research on flours from local crops to replace wheat or use in conjunction with wheat flour to reduce the cost on wheat importation and subsequently cost of production. This has led to the various works on composite flour (Igbabul *et al* 2012, Chinma *et al*, 2012, Adeleke and Odedeji, 2010) which has higher nutritional advantage over individual flours and subsequent products.

Composite flour can be defined as a mixture of several flours obtained from roots , tubers, cereals and legumes with or without the addition of wheat flour (Shittu *et al.*, 2007, Adeyemi and Ogazi, 1985). Composite flours have been used extensively and successfully in the

production of baked goods. It is considered advantageous in developing countries as it decreased the

Table 1. Formulation of composite flours of Wheat, Sweet potato and Hamburger bean seed

Flour blend	WF (%)	SPF (%)	HBF (%)
A (control)	100	-	-
B	90	5	5
C	80	10	10
D	70	15	15
E	60	20	20

Key: WF = Wheat flour, SPF = Sweet potato flour, HBF = Hamburger bean flour.

importation of wheat flour and encouraged the use of locally grown crops as flour (Hugo *et al*., 2000). Composite flours are produced from roots and tubers such as yam, cassava, sweet potato, cocoyam among others in conjunction with legumes including cowpea, peas, chickpeas, lima beans, common beans and soybeans plus lesser known ones which have remained either unexplored or are underutilised (Arinathan *et al*., 2003) among which are pigeon peas (bambara groundnut (*Voandzeia subterranean*), hamburger bean seed (*Mucuna sloanei*) and pigeon peas (*Cajanus cajan*).

Hamburger bean seed (*Mucuna sloanei*) is naturally found in tropical and sub-tropical regions of the world. It is an underutilized legume in Africa that possess adequate protein, carbohydrate, fat and ash that is comparable to other common legumes (Igbabul *et al,* 2012). It belongs to the family leguminosae, some other species of *Mucuna* includes *Mucuna Urensi, Mucuna pruries,* and *Mucuna reracruz* (Nkpa, 2004). It is also called horse eye bean, velvet bean and devil bean with other local names in respect to different tribes and ethnic groups. It is called 'ukpo' by the Ibos, 'yerepe' by the Yorubas and 'karasau' by the Hausas (Ayozie, 2010). Hamburger bean seeds contribute immensely to the human nutrition as it contains high content of protein especially when it is fermented (Igbabul *et al*., 2012). They are good source of phosphorus, but only fair in their supply of iron and calcium (Okaka *et al.,* 2006). Flour from hamburger bean seed is traditionally used in most states in Nigeria including Imo, Anambra, Akwa Ibom, Benue and Ondo State as soup thickeners, emulsifiers as well as flavouring agents in traditional soups (Enwere, 1998). They are usually limited in the sulphur containing amino acids particularly methionine which are found in cereals such as wheat (Eggum & Beame, 1983), thus composite flour of wheat, sweet potato and hamburger bean would complement each other by providing the limiting amino acids to combat malnutrition and hunger.

The sweet potato (*Ipomoea batatas*) is an economic and healthful food crop containing beta-carotene and substantial amounts of ascorbic acid, niacin, riboflavin, thiamin and minerals (Woolfe,1992, Gopalan et al,1989). It has a large potential to be used as a food in developing countries with limited resources because of its short maturity time and ability to grow under diverse conditions and on less fertile soil. Generally, the tubers are consumed in fresh form, cooked by roasting, frying or boiling and can also be used as a raw material for the feed industry (Zuraida, 2003). Sweet potato can be processed into different products for value addition. The most promising ones are dried chips, starch and flour (Colins, 1989). Sweet potato flour can be a source of natural sweetener, dietary fibre and energy in bakery goods and beverages and add flavor and colour to many other processed products (Woolfe, 1992) . Flours from starchy tubers such as potatoes are inadequate in proteins which can be obtained from blending with legume flours such as hamburger bean flour to enhance the necessary nutrients for nourishment (Boruch,1985, Afoakwa and Sefa-Dedeh 2001).

Blending of hamburger bean flour, sweet potato and wheat flour would provide nutrient rich flour blends for utilization in production of many food products for both children and adult, such as cakes, bread, doughnuts, porridge. This would combat hunger, protein-energy malnutrient and enhance use of underutilized indigenous crops in ensuring food security. The aim of this work is therefore to produce flour blends from wheat, sweet potato and hamburger bean and study the proximate composition and functional properties for possible utilization in production of value added products at the household and industrial level.

MATERIALS AND METHODS

Source of raw materials

Sweet potato (*Ipomoea batatas*) and hamburger bean seed (*Mucuna sloanei*) were bought from a local market in Markudi, Benue State, Nigeria. The wheat flour was a commercial baker's grade bought from North Bank market, Markudi, Benue State. All chemicals used in the analysis were of analytical grade.

Preparation of raw materials

Production of hamburger bean seed flour: The hamburger bean seed flour was prepared using the method of

Table 2. Proximate compositions of wheat, sweet potato and hamburger bean seed flour blends

Parameter (%)	A	B	C	D	E	LSD
Moisture	10.00^{a}±0.00	9.64^{b}±0.10	9.28^{c}±0.12	8.93^{d}±0.10	8.57^{e}±0.12	0.38
Ash	1.39^{a}±0.10	1.44^{b} ±0.12	1.48^{c}±0.10	1.58^{d}±0.12	1.57^{d}±0.10	0.03
Fibre	2.49^{a}±0.10	2.41^{ac}±0.10	2.33^{bd}±0.12	2.24^{d}±0.12	2.16^{d}±0.10	0.08
Fat	2.19^{a}±0.10	2.59^{ac}±0.10	2.99^{bd}±0.12	3.39^{ce}±0.10	3.79^{e}±0.12	0.50
Protein	12.05^{a}±0.12	12.51^{a}±0.10	13.60^{b}±0.10	14.27^{c}±0.10	15.15^{d}±0.10	0.15
CHO	71.83^{a}±0.12	71.35^{a}±0.10	70.26^{b}±0.10	69.48^{c}±0.12	68.70^{d}±0.10	0.50

Values are mean±Standard deviation of duplicate determinations. Means with the same superscripts within the same row are not (P>0.05) significantly different.
LSD: Least significant different, CHO = carbohydrate by difference

Table 3. Functional properties of wheat, sweet potato and Hamburger bean seed Flour Blends

Parameter (%)	A	B	C	D	E	LSD
pH	6.01^{a}±0.12	5.71^{b}±0.10	5.67^{b}±0.10	5.59^{c}±0.10	5.45^{d}±0.10	0.06
WAC	2.44^{a}±0.10	2.55^{b} ±0.12	2.66^{c}±0.10	2.77^{d}±0.10	2.87^{d}±0.10	0.10
BD(g/ml)	7.46^{a}±0.10	7.08^{b}±0.12	6.71^{c}±0.10	6.33^{cd}±0.10	5.96^{d}±0.10	0.19
SC(%)	7.08^{a}±0.12	7.50^{b}±0.10	7.59^{c}±0.10	7.99^{d}±0.12	8.62^{e}±0.12	0.11
V(B.U)	71.50^{a}±1.22	67.00^{a}±0.10	60.00^{b}±0.10	54.00^{c}±1.22	46.05^{d}±1.22	1.50
FC(%)	4.11^{a}±0.10	4.07^{ab}±0.12	4.05^{b}±0.12	4.00^{d}±0.10	3.95^{e}±1.22	0.04
FAC	1.59^{a}±0.10	1.74^{a}±0.10	1.87^{b}±0.10	2.01^{b}±0.10	2.14^{c}±0.12	0.13
EC(%)	14.67^{d}±0.10	16.09^{c}±0.10	17.51^{b}±0.10	18.93^{a}±0.12	20.34^{a}±0.10	0.72

Values are mean±Standard deviation of duplicate determinations. Means with the same superscripts within the same row are not (P>0.05) significantly different.
LSD: Least significant different.
Key: WAC = Water absorption capacity, BD = Bulk density, SC= Swelling capacity, V = Viscosity, FC = Foaming capacity, FAC = Fat absorption capacity, EC = Emulsion capacity.

Onyemelukwe and Enwere (1992) as modified by Igbabul *et al*, (2012). The brown hamburger bean seeds were sorted to remove extraneous materials. Sorted seeds were cracked using a hammer, fermented for 72 hr and dried in the oven (60°C) and grinded into flour in the laboratory using disc attrition mill and sieved to a particle size of 100µm to obtain hamburger bean seed flour.

Production of sweet potato flour

Sweet potato flour was prepared as described by Singh *et al*, (2008). Sweet potatoes were sorted, peeled, washed and cut into thin slices manually. The slices were directly immersed in solution containing KMS (1%) for 30 min. Drying of sweet potato slices was done by spreading on a tray covered with aluminum foil and oven dried at 60°C for 24 hr to moisture content 7-8%. The dried slices were milled after cooling using a disc attrition mill and sieved to a particle size of 100µm to obtain sweet potato flour.

Formulation of composite flours

Composite flours consisting of different proportions of wheat, sweet potato and hamburger bean flour were prepared as shown in Table 1, 100% wheat flour served as the control. The flours were weighed and mixed together using a digital weighing balance and a blender (Philips, HR 1702).

Determination of proximate composition

Protein Content

The protein content was determined using a micro-Kjedhal method (AOAC,2005) which involves wet digestion, distillation, and titration. The protein content was determined by weighing 3 g of sample into a boiling tube that contained 25 ml concentrated sulfuric acid and one catalyst tablet containing 5 g K_2SO_4, 0.15 g $CuSO_4$

and 0.15 g TiO_2. Tubes were heated at low temperature for digestion to occur. The digest was diluted with 100 ml distilled water, 10 ml of 40% NaOH, and 5 ml $Na_2S_2O_3$, anti-bumping agent was added, and then the sample was diluted with 10 ml of boric acid. The NH_4 content in the distillate was determined by titrating with 0.1 N standard HCl using a 25 ml burette. A blank was prepared without the sample. The protein value obtained was multiplied by a conversion factor, and the result was expressed as the amount of crude protein.
% crude protein = Actual titre value – Titre of the blank x 0.1N HCl x 0.014 x conversion factor x 100/ weight of the sample.

Fat Content

Fat content was determined using the method of (AOAC, 2005). About 10 g of sample wrapped in a filter paper was weighed using a chemical balance. It was then placed in an extraction thimble that was previously cleaned, dried in an oven, and cooled in the desiccator before weighing. Then, about 25 ml of petroleum ether solvent was measured into the flask and the fat content was extracted. After extraction, the solvent was evaporated by drying in the oven. The flask and its contents were cooled in a desiccator and weighed.
The percentage fat content was calculated as follows:
Percentage of Total fat content = $\frac{\text{weight of fat extracted}}{\text{weight of food sample}}$ x 100

Crude Fibre

Crude fibre was determined using the method of (AOAC, 2005). About 5 g of each sample was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm no. 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccators and weighed as W_1 . It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2.
Percentage crude fibre = $\frac{W_1 - W_2}{W_0}$ x 100
W_1=weight of crucible+fibre+ash
W_2=weight of crucible+ash
W_0=Dry weight of food sample

Ash Content

Ash content was determined using the method of (AOAC, 2005). About 5 g of each sample was weighed into crucibles in duplicate, and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the desiccators to avoid absorption of moisture and weighed to obtain ash content.

Moisture Content

Moisture content was determined using Association of Official Analytical Chemist (AOAC, 2005). About 5 g of sample was weighed into Petri dish of known weight. It was then dried in the oven at 105 ± 1°C for 4 hours. The samples were cooled in a desiccators and weighed. The moisture content was calculated as follows:
Percentage moisture content = $\frac{\text{Change in weight}}{\text{Initial weight of food before drying}}$ x 100

Total Carbohydrate Content

Carbohydrate content was determined by difference using the method of Egounlety and Awoh (1990), by subtracting the total sum of the percentage of fat, moisture, ash, crude fibre, and protein content from hundred (100).

Determination of functional properties

Water and oil absorption capacities

The water and oil absorption capacities were carried out according to the method described by Sosulski et al (1976). Ten ml distilled water or oil was mixed with I g of the flour sample, the mixture was allowed to rest at 30 ±2 ^{o}C for 30min and then centrifuged at 200g for 30 min and finally the water and oil absorption capacities of the flour were expressed as grams of water or oil absorbed by I g of the flour sample.

Swelling Capacity (SC)

Swelling capacity was determined according to the method given by Robertson *et al* (2000). About 100 mg of the sample was mixed with 10 mL of distilled water in a calibrated cylinder at room temperature. After equilibration for18 hr, the bulk volume was recorded and swelling capacity expressed as volume occupied by sample per gram of original sample dry weight.
Swelling capacity % = change in volume of sample/ original weight of sample.

Foaming capacity (FC)

This was determined by the method described by

Coffman and Garcia (1977). About 2 g of sample was blended with 100 ml distilled water in a Kenwood blender. The suspension was whipped in an ace homogenizer (NSEIAM-6) at 1600rpm for 5 minutes. The mixture was poured into a 250ml graduated cylinder and the volume was recorded after 30 seconds. The foaming capacity was expressed as percentage increase in volume using the formula:

$$\text{Foam capacity}(\%) = \frac{\text{volume after whipping} - \text{volume before whipping}}{\text{volume before whipping}} \times 100$$

Bulk density

This was determined using the method described by Onwuka (2005). About 2.5 g of sample was filled in a 10 ml graduated cylinder and its bottom tapped on the laboratory bench until there was no decrease in volume of the sample. The volume was recorded.

$$\text{Bulk density} = \frac{\text{weight of sample}(g)}{\text{volume of sample}(mL)}$$

Viscosity

This was determined using the Bradender amylograph as reported by Adeleke and Odedeji (2010). The procedure involved dispensing 200 g suspension of 10% (w/v) preparation of each sample into the equipment and monitoring the viscosity of the slurry as the temperature increases.

Emulsion capacity

This was determined by the method described by Onwuka (2005). Two grams of the flour sample was blended with 25 mL of distilled water at room temperature for 30 sec in a kenwood blender (BL 330 series). After complete dispersion, 25ml of vegetable oil was gradually added and blending continued for another 30 sec. Then 15 mL of the flour sample was transferred into a centrifuge at 1600 rmp for 5 min, then the volume of oil separated from the sample after centrifuge was read directly from the table.

Emulsion capacity is expressed as the amount of oil emulsified and held per gram of oil emulsified and held per gram of sample.

Emulsion capacity = X/Y x 100

Where X = height of emulsified layer

Y= height of whole solution in the centrifuge tube

pH Measurement

The pH of the sample was measured with a pH meter as described by Onwuka (2005) .About 10% W/V suspension of the sample was prepared in distilled water and mixed thoroughly in a kenwood blender (BL 330 series), then the pH was taken after standardizing with buffer solutions of pH 4.0 and 7.0.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) as described by (SAS, 1999). The means were then separated with the use of Duncan's multiple range test, compared by Least Significant Difference (LSD) with mean square error at 5% probability using the statistical package for the social sciences, SPSS 19.0 software.

RESULTS AND DISCUSSION

Table 2 shows the results of the proximate composition of wheat, sweet potato and hamburger bean seed flour blends. The flour blends showed significant increase ($p < 0.05$) in protein ranging from 12.05- 15.15%, with increase in hamburger bean flour. The result showed no significant difference in protein content at 5% substitution of sweet potato and hamburger bean flour. Similar results were reported by (Okoye *et al*, 2010 and Yusufu *et al,* 2013)The carbohydrate content on the other hand showed significant decrease with increase in hamburger bean flour with a range of 71.83-68.70%. This trend in increase in protein content and decrease in carbohydrate content with increasing hamburger bean flour is expected since hamburger bean flour is rich in proteins and fats, (Igbabul *et al*., 2012).

The fat content ranged from 2.19-3.79% and increased significantly with increase in hamburger bean flour substitution. This implies that foods prepared using this composite flour would be energy dense foods suitable for people such as sportsmen that require lot of energy to work.

The crude fibre ranged from 2.49-2.16% in decreasing order. The decrease was significant at 5-15% level of substitution after which there was no significant decrease. The value at 20% substitution was however lower than the 15% level.

The moisture content of the flour blends decreased significantly from 10.00-8.57% with the control sample having the highest moisture content of 10%. The low values of moisture content in this study would enhance the storability and keeping quality of the products.

There was significant increase ($p<0.05$) in ash content of the flour blends with a range of 1.39-1.57% with increase in potato flour and hamburger bean flour substitution. Ash content is indicative of the amount of minerals in any food sample. The increase in ash is indicative of high mineral content of potato and hamburger bean flour.

The result of functional properties of wheat, sweet potato and hamburger bean seed flour blends are as presented in Table 3. The functional properties determine the application and use of food material for various food products.

The pH of flour samples decreased significantly ($p<0.05$) from 6.01- 5.45 with the control sample having the highest value. The decrease in pH values could be as a result of addition of fermented hamburger bean flour resulting in increased acidity. Acidic products are more shelf stable than their non acidic counterpart (Ihekoronye and Ngoddy, 1985). The increase in acidity is of great significance as it was reported to reduce the incidence of diarrhea in infants consuming fermented maize porridge (Mensah *et al*., 1990).

The water absorption capacity increased significantly with increase in sweet potato and hamburger bean flour substitution. The values ranged from 2.44-2.87g/mL with the control sample having the least value. These values were higher when compared to that of Adeleke and Odedeji (2010), this could be attributed to the addition of sweet potato and hamburger bean seed flour to the blend. The lower water absorption capacity of the wheat flour could be attributed to the presence of lower amount of hydrophilic constituents in wheat (Akubor and Badifu, 2001).

The oil absorption capacity increased significantly from 1.59-2.14%. The control sample of 100% wheat flour recorded the least value .The oil absorption capacity (OAC) of flour is important as it improves the mouth feel and retains the flavour. The higher OAC suggested the presence of apolar amino acids in the flour blends from the addition of hamburger bean flour.

Protein concentration and their conformational properties in foods also influence oil absorption.(Ahmad and Prakash, 2006, Ige et al 1984). The composite flour of wheat, hamburger bean flour and potato could be useful as functional ingredient in foods such as whipped toppings, sausages and sponge cakes.

The bulk density decreased significantly with increase in the potato and hamburger bean flour substitution levels. The values for the samples ranged between 7.46-5.96g/ml. Bulk density is generally affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in food industry (Karuna *et al*., 1996). The values in this study are higher than those reported by Ijarotimi and Aroge, 2005 on composite flour of breadfruit and soybean but also lower than those reported by Tiwari et al, 2008 in their study on pigeon pea flours.The lower the bulk density, the higher the amount of flour particles that can bind together leading to higher energy values.(Onimawo and Egbekun, 1998).

Swelling capacity is an indication of the water absorption index of the granules during heating (Loos *et al.,* 1981). The swelling capacity increased significantly with increase in sweet potato and hamburger bean flour substitution ranging from 8.62-7.50%. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations.

Addition of sweet potato and hamburger bean flour to the wheat flour increased the hydrophilic groups in the flour leading to increased water absorption. Thus, the flour would be useful in food systems that need water in preparation such as bakery foods.

There was significant decrease in viscosity values of the flour samples in the range of 71.5-46.05 B.U. This might be due to the higher gluten content in wheat flour.

Emulsion capacity showed significant increase with increase in sweet potato and hamburger bean flour. The control sample had the lowest value of 14.67% while sample E had the highest value of 20.34%. The emulsion capacity reflects the ability of the sample to rapidly adsorb at the water-oil inter phase during the formation of emulsion, thereby preventing flocculation and coalescence (Subago, 2006). The values recorded are lower than 48.93% reported by (Shad *et al*, 2011) for lotus flour.

Foaming capacity of the flours decreased significantly with increase in sweet potato and hamburger bean flour. The values ranged from 4.11-3.95%. The foamability of the flour depends on the presence of the flexible protein molecules which may decrease the surface tension of water (Sathe *et al*., 1982

CONCLUSION

Supplementation of wheat flour with sweet potato and hamburger bean seed produced composite flour with higher nutritional value as evidenced in increased ash content signifying increased micronutrients and protein content. The functional properties of the flour blends were also greatly improved. The flour blend is therefore a potential raw material in food production at household levels and for industrial purposes to combat hunger and provision of nutritious foods to fight malnutrition problems on African content and developing countries.

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