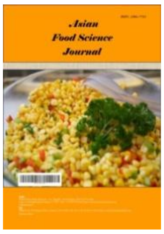

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Pasting Properties of Composite Flour Made from Sorghum, Millet and African Yam Bean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this research was to produce acceptable 'fufu' from a mixture of sorghum, millet, and African yam bean flours that will have a moderate carbohydrate and protein content with most optimized texture. The functional and sensory properties of flour blends produced from Sorghum, Millet and African yam bean was studied. Sorghum, Millet and African yam bean were processed into flour and mixed at different ratios to obtain composite flours. The flour formulations obtained were analyzed for water absorption capacity, bulk density, least gelation concentration , and viscosity .The water absorption capacity ranged from 1.00 to 3.00, the bulk density ranged from 0.56 to 0.82;the least gelation concentration ranged from 5.77 to 6.87,while the viscosity ranged from 0.956 to 9.30.Also proximate composition of the individual flours before formulation was analyzed, it ranged from 6.13 to 8.46 moisture, 2.00 to 4.67 ash, 0.17 to 8.00 fiber,5.47 to 8.61 fat, 7.57 to 21.84 protein, 58.34 to 69.27 carbohydrate.The sensory values ranged from 5.60 to 6.45 for taste; 4.25 to 6.85 for colour; 5.15 to 6.80 for texture; 3.85 to 5.70 for aroma; 5.45 to 6.45 acceptability. Sample 10 (with the ratio of 40:70:20) had the highest rating for general acceptability. It was observed that sample 1(with the ratio of 60:50:60) had the lowest rating in taste and aroma. The mixture components that could produce optimum texture was determined through optimization plot. This work has demonstrated that acceptable 'fufu' with moderate protein and carbohydrate could be successfully produced using composite flours of sorghum, millet and African yam bean.

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Keywords: Sorghum; millet; African yam bean.

1. INTRODUCTION

Grain crops like sorghum, millet, maize, beans, soybeans, African yam bean contribute immensely to food security of the world. The cereal grains are the world's biggest source of energy despite widespread consumption, the health effects of grains are quite controversial. The first cereal grains were domesticated by early primitive humans [1]. Lantican [2] defines cereals as agronomic crops belonging to the grass family which are utilized as staple. In Africa, most of the breakfast meals for both adult and young kids are prepared from cereals, legumes, roots and potato. Faber et al. [3] stated that cereals are processed to detoxify the antinutrional factors, increase palatability, digestibility, and to improve bioavailability.

Sorghum (*Sorghum bicolor*) is a cereal native to sub-Saharan Africa and grows well in temperate and tropical areas of the world where other staple cereals such as maize, wheat and rice cannot grow well [4]. It is consumed as porridge, malted and distilled beverages in Africa and Asia. It is used for the production of syrup, animal feed and ethanol in the United States and other developed countries [4].

Millets are important foods in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. India has the largest millet producing country in the world with a total area of 23 million ha and small millets alone account for about 3.5 million hectare1. The major millets are pearl millet, foxtail millet, proso millet and finger millet. The most important minor millets cultivated in India are barn-yard millet, kodo millet, little millet, guinea millet and brown top millet. Millets are more nutritious and they are non-glutinous and non-acid forming and easy to digest Millets are rich sources of phytochemicals, micronutrients and antioxidants, such as phenolic acids and glycated flavonoids [5].

Grain legumes also called pulses are plants belonging to the family (*Leguminosae*) or (*Fabacea*) which are grown primarily for the edible seeds. As defined further by FAO [6]. Pulses exclude those that are used mainly for the extraction of oil such as soybean. Grain legumes are important constituent in the diets of a very large number of people especially in the developing countries and are good sources of protein which helps to supplement cereal diets by improving their protein nutrition value.

African yam bean (*Sphenostylis stenocarpa*) is a legume crop that is cultivated by the traditional farmers in many parts of Nigeria. According to Akande [7], the crop is an annual with vine-like stems that requires taking. Due to its climbing characteristics, the crop is usually inter-cropped with yam so that its vines can utilize yam stake for climbing thereby saving labour for staking it as a sole crop.

Carbohydrate and protein are essential to human diets for energy and growth respectively [1]. However, some cereal grains are deficient in the essential amino acid methionine, this is why they are combined often in order to get a balanced diet. The effect of high consumption of cereal products is not very well understood and ascertained. The starch and protein content of the cereals is greatly affected by the genetic and environmental factors. Starch contained in some cereals are not easy to digest (such as sorghum) and also the use of only gluten rich flours causes celiac disease but substation with other grains improves palatability and acceptability. For this reason, this work is centered on production of composite flours from three grain crops which are sorghum, millet, and African yam bean and the goal of this study is to characterize the flow, consistency, and deformation of the composite flours under specified conditions by understanding their textural and stability behaviours as related to processing and consumption. The aim of this research was to produce acceptable 'fufu' from a mixture of sorghum, millet, and African yam bean flours that will have a moderate carbohydrate and protein content with most optimized texture. The findings from this study was used to optimize the production of composite flour from the blend of the three raw materials to finally produce an acceptable fufu which compares favourably with commonly consumed wheat. Again, mathematical model equations was developed through simple multiple regressions that could be used as predictive models for any desired attribute(s) of the product.

2. MATERIALS AND METHODS

2.1 Experimental Design

The experiment was designed using statistical software(MINITAB version 16.0). The experiment is a central composite design (Face centered) having three components: Sorghum flour(X_1), Millet flour(X_2) and African yam bean flour(X_3) at varied ratios as shown in Table 1 below.

Table 1. Formulation of composite flours

Samples	Sorghum X_1	Millet X_2	AYB X_3
1	60	50	60
2	80	70	60
3	40	50	40
4	60	50	40
5	80	30	20
6	40	30	60
7	40	70	60
8	60	50	20
9	80	50	40
10	40	70	20
11	80	30	60
12	80	70	20
13	60	70	40
14	60	30	40
15	40	30	20

2.1.1 Materials

The materials Sorghum bicolor and pearl millet were purchased from Eke-Awka market in Anambra state, Nigeria. While African yam bean was purchased from Ogbete market in Enugu state, Nigeria.

2.1.2 Preparation of sorghum flour

The sorghum flour was prepared according to the method of Gouri and Pongodi [8]. During preparation, 1kg of sorghum grains which were free from dirts and other foreign particles such as stones, leaves, sticks were weighed, cleaned and soaked in 3 liters of portable water at room temperature for 24hrs.The soaked grains were washed, dried in a hot air oven (Model S-936R] at 60^{o}C for 12hrs.The dried grain obtained was milled in an attrition mill and sieved in a 500 micron mesh sieve. The sorghum flour obtained was packaged in an airtight polyethylene bag.

2.1.3 Preparation of millet flour

The millet flour was produced with the method of Fasasi [9] with little modification as shown in Fig 3 where 1kg of the grains free from dirts and foreign materials were weighed ,cleaned and soaked for 48hrs ,washed and dried in a hot air oven(Model S-936R)at 60^{o}C for 14hrs.The millet grains obtained was milled with an attrition mill and sieved in a 500 micron mesh sieve. The flour was packaged in a polyethylene bag.

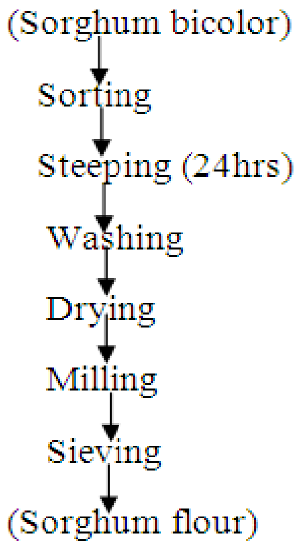

Fig. 1. Flow chart for the production of sorghum flour

2.2 Preparation of African Yam Bean Flour

The African yam bean flour was prepared using the method of Ojukwu et al. [10]. The African yam bean seeds was sorted to remove dirts, unwholesome seeds and foreign materials.1kg was weighed and steeped for 24hrs in room temperature, after which washing was done. The seeds were dried in a hot air oven (Model S-936R) at 60^{0}C for 10hrs.The seeds were milled using an attrition mill and sieved using 30µm.The flour gotten was packaged in a polytheyne bag.

2.3 Method of Analysis

2.3.1 Water absorption capacity

The method described by Majzoobi and Abedi [11] was employed in the determination of the water absorption capacity of the flour samples. One gram of the flour was mixed with 10 ml of water in a centrifuge tube and allowed to stand at room temperature (30 ± 2°C) for 1 hr. It was then centrifuged at 5000 rpm for 30 min. The volume of free water on the sediment water was read from the calibrated centrifuge tube. Water absorption capacity was calculated as ml of water absorbed per gram of flour (i.e. the difference in volume of the initial amount of water added to that decanted after centrifugation).

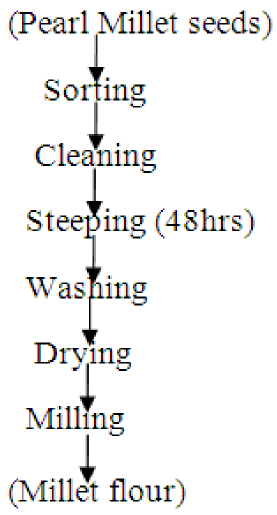

Fig. 2. Flow chart for the production of pearl millet flour

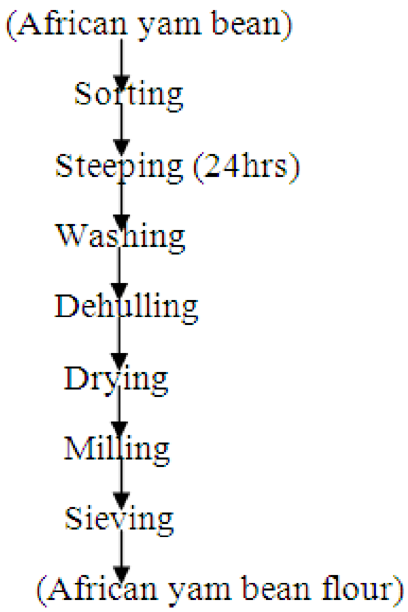

Fig. 3. Flow chart for the production of African yam bean flour

2.3.2 Least gelation concentration

The method of Onwuka [12] was used to determine the least gelation concentration. Sample suspensions of 2-20% (w/v) was dissolved respectively in a boiling test tube containing 5 mL of distilled water and heated for 1h in a boiling water bath. The heated dispersion was cooled rapidly under running cooled water and then cooled further at 40°C for 2 h. Gelation was determined either by its ability to flow or not in test tube when slanted. The gelation concentration determined as the concentration when the sample from the inverted, test tube did not fall or slip.

2.3.3 Bulk density

The method of Onwuka [12] was used.10g of the samples was poured into a 10ml graduated cylinder. The bottom of the cylinder was tapped gently on the laboratory bench until no further dimunition of the sample level after filling . The bulk density was determined;

$$\text{Bulk density (g/ml)} = \frac{\text{weight of sample}}{\text{Volume of sample}}$$

2.3.4 Viscosity

The method of Onwuka [12] was used for the viscosity measurement. 10 grams of sample was weighed and emptied into a beaker after which 100 mL of distilled water was added. The mixture was then stirred properly for 2 h at room temperature. Using Oswald type viscometer, viscosity was measured.

2.4 Proximate Composition

2.4.1 Moisture content determination

The moisture content of the samples was determined in accordance with the method described by Uzoma et al. (2002). 2 grams of the sample were weighed into a pre-weighed dish provided with a lid. It was dried in an oven at 130°C for 1 h. It was cooled in a dessicator and weighed. The process was repeated until the dried sample weight is constant. The percentage moisture content was calculated as below;

% M.C= (Wt. of the Sample before drying-wt. of sample after drying / Weight of the sample before drying) × 100

2.4.2 Ash content determination

Ash content was determined on 2 grams of each sample which was weighed into a porcelain crucible and evaporate to dryness or small volume in an oven set at 100°C. Later the samples was charred on a heater inside a fume cupboard to drive off most of the smoke and transferred into a pre-heated muffle furnace at 500°C, left at this temperature for 2 h until a white or light grey ash resulted. The crucible and its content was cooled at about 100°C, then room temperature in a dessicator and weighed. The weight of the residue was calculated as ash content expressed in percentage [13].

$$\% \text{ ash content} = \frac{\text{Weight of ash}}{\text{Original weight of sample}} \times 100$$

2.4.3 Crude protein determination

The Micro-kjedahl method described by AOAC [13] was used. 2 grams of each sample was mixed with 10mL of concentrated H_2SO_4 in a heating tube and one tablet of selenium catalyst added to the tube and the mixture heated inside a fume cupboard. The digest was transfered into a 100ml volumetric flask and made up with distilled water. 10mm portion of the digest was mixed with equal volume of 45% NaOH solution and poured into a kjedahl distillation apparatus. The mixture was then distilled and the distillate collected into a 4% boric acid solution containing 3 drops of Zuazaga indicator. A total of 50mm distillate was collected and titrated as well. Each sample was duplicated and the average value taken. The nitrogen content was calculated and multiplied with 6.25 to obtain the crude protein content. This is given as;

$$\% \text{ Nitrogen} = \frac{(100\times N\times 14\times Vf)}{100} \times \frac{Va}{1}$$

Where,

N= Normality of the litre (0.1N)
Vf= Total volume of the digest =(100ml)
T= Titre value
Va= Aliquot volume distilled

2.4.4 Crude fibre determination

The method described by AOAC [14] was employed .2 g of the sample was accurately put into the fibre flask and 100ml of 0.255N H_2SO_4 added. The mixture was heated under flux for 1h with the heating mantle. The hot mixture was filtered through a fibre sieve cloth. The filtrate obtained was thrown off and the residue was returned to the fiber flask to which 100 mL of 0.313N NaOH was added and heated under reflux for another 1h. The mixture was filtered through a fibre sieve cloth and 10 mL of acetone was added to dissolve any organic constituent. The residue was washed with about 50 mm hot water on the sieve cloth before it was finally transferred to the crucible. The crucible and residue was oven dried at 105°C to drive off moisture. The oven dried crucible containing the residue was cooled in a dessiccator and later weighed to obtain the weight, W_1. The crucible was transferred to the muffle furnace for ashing at 550°C for 4h. The crucible containing white or grey ash (free of carbonaceous material) was cooled in the dessicator and weighed to obtain, W_2. The difference, W_1-W_2, gives the weight of the weight of the fibre. The percentage fibre was obtained by the formular below as described by AOAC [14].

$$\% \text{ Fibre} = \frac{\text{Weight of fiber}}{\text{Weight of sample}} \times 100$$

2.4.5 Crude fat determination

250 ml clean boiling flask was oven dried at 105-110°C for 30min before it was transferred to a dessiccator to cool. 2g of the sample was weighed out accurately into labeled thimbles and also correspondingly labeled. Cooled boiling flask was weighed. 300mm of petroleum ether (boiling point 40-60°C) was filled into the flask, after which the extraction thimble was plugged lightly with cotton wool. The soxhlet apparatus was assembled and allowed to reflux for about 6h. The thimble was removed with care and petroleum ether collected in the top container of the set-up and drained into a bottle for re-use. When the flask was almost free from petroleum ether, it was removed and dried at 105-110°C for 1h, after which it was cooled in a dessiccator before weighing.

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

2.4.6 Carbohydrate content determination

The nitrogen free extract (NFE) described by AOAC [14] was used. The carbohydrate was calculated by the difference between hundred and the summation of other proximate parameters as Nitrogen Free Extract (NFE).

% Carbohydrate (NFE)= 100- (%M+ Cp+ %A+ $\%Cf_1$+ $\%Cf_2$)

Where,

A= Ash
M= Moisture
Cp= Crude Protein
Cf_1= Crude Fat
Cf_2= Crude Fibre

2.5 Sensory Analysis

Sensory evaluation was determined according to the method described by Oyeyinka et al. [15] using 20 member panelist. The 20 member panelist were briefed on how to make judgements. Samples were presented to a panel of 20 semi trained judges selected from the Department of Food Science and Technology, Nnamdi Azikiwe University, Awka. Organoleptic characteristcs of the fifteen samples with the control were assessed by descriptive sensory profile on taste, color, texture, aroma, and overall acceptability using the 9 point hedonic scale ranging from 1 indicating dislike extremely to 9 indicating like extremely with neutral category of 5 indicating neither like nor dislike.

2.6 Statistical Analysis

The statistical analysis was conducted using one-way ANOVA procedures which is dependent on the experimental design. Statistical differences in samples was tested for at $p < 0.05$. Least significant difference (LSD) was used to differentiate between the mean values. All the analyses were done with SPSS (17.0) software. Minitab was used to generate regression coefficient that was fitting the mathematical models which explained the relationship between the response variable and the mixture components.

3. RESULTS AND DISCUSSIONS

3.1 Functional Properties

Functional properties are the intrinsic physiochemical characteristics which may affect the behavior of food systems during processing and storage .These properties will decide the acceptability of the product.

3.1.1 Water absorption capacity

The water absorption capacity is an index of the water absorbs and retain. The water absorption is shown in Table 1.The blend range from 1.00 ± 0.00 – 3.00 ± 0.00 g/ml Sample 15 with the ratio of 40:30:20 of sorghum, millet and African yam bean has the highest water absorption capacity. The increase in water absorption capacity could be attributed to the presence of high hydrophilic constituents [16]. Also the water absorption capacity of the dry composite flours was low probably due to the processing methods. Similar results was obtained by Igabul et al. [17] in his work on effect of fermentation on the proximate composition and functional properties of defatted coconut (*Cocos nucifera L.* flour) which range from 2.00± 0.05-2.70±0.14.High water absorption capacity is related to the extent of gelatinization. Respective content of hydrophilic constituent such as carbohydrates which bind more water than either protein or lipids. Both carbohydrates and protein are more soluble in water. Nibia et al. [18] stated that WAC is important in bulking and affects the consistency of products. High WAC of composite flours suggests that the flours can be used in formulation of some foods such as sausage, dough and bakery products [19].

3.1.2 Bulk density

Table 1 shows the bulk density of the flours. The bulk density range from 0.56±0.25- 0.82 ±0.00 g/mL. However there was a significant difference ($p>0.05$) between the formulations. Suresh *et al*. [20] reported that bulk density depends on the combined effects of interrelated factors such as the intensity of attractive inter-particle forces, particle size, and number of contact points. The result is similar to that of Igbabul et al. [17] on sweet detar and hamburger bean flour. Also Onimawo and Akubor [21] reported that germination and fermentation leads to decrease in the bulk density of foods. Carr [22] rightly observed that most food flours are cohesive meaning that their inter-particle attractive forces are significantly higher relative to the particle on weight, inter alia and with respect to the powders the additive effects and characteristic individual particles compromising a powder system may be different from those of the powder or flour in bulk. The processing method could have led to the lower bulk. Bulk density value is important in packaging. Nutritionally loose or lower bulk density promotes digestibility of the food product. Low bulk density of the blends as obtained in this study is a good physical attribute during transportation since the products can be easily transported and distributed to different locations.

3.1.3 Least gelation concentration

The least gelation concentration data is presented in Table 1. The flour formulations range from 5.77±0.06-6.87±0.06 g/ml. From the results, the control (whole wheat flour) had the highest least gelation concentration with a value of 10.23±0.251 g/mL. This could be due to the increase in the concentration [23] which resulted in the rapid change in the consistency of the protein when heat was applied to form a 3-dimensional continuous network which traps and immobilizes the liquid within it to form a rigid structure that is resistant to flow under pressure. Gelation is an aggregation of denatured molecules. Processing conditions may have denatured the control and, thus, caused more aggregation than in the other flour samples sorghum flour.

3.1.4 Viscosity

Table 2 shows the viscosity measurements, values of viscosity range from 0.95±0.05-1.42±0.00 mpa.s. This increase could be attributed to an increase in the effective volume of the protein which generally results from increased molecular asymmetry brought about by a change from highly compact to an elongated random coil [21]. The generally low viscosity observed ER may be due to less disruption of intermolecular hydrogen bonds that brought about noticeable swelling of the granules and gelation [24].

3.2 Proximate Composition

The proximate composition of individual grains is shown in Table 4.The moisture content of the dehulled African yam bean flour was very significant (P< 0.05) and this was attributed to the dehulling. This meets the desirable not more than 15.5% moisture content of flour as given by [25]. The values are therefore low enough for adequate shelf life stability if packaged in moisture-proof containers .The fat content for individual flours ranges from 5.47±0.42-8.61 of which there was a significant difference (p<0.05) .The ash contents of the flour samples ranged from 2.00±0.00-4.67±0.58, of which millet had the highest value while sorghum and African yam bean compared favourably. The values obtained shows the presence of some minerals in the flour samples. The protein content of the flour samples ranged from 7.57±0.28-21.84±0.06. Significant (p<0.05) differences were observed among the samples. The crude protein for the dehulled African yam bean flour was significantly different (P < 0.05) from millet and sorghum and this was attributed to the soaking and dehulling operations given to it making to obtain the highest value. This high value could be attributed to to net synthesis of enzyme protein. The protein content is in agreement of study done by Eromsole et al. [26]. Millet grains are known to contain appreciable amount of protein of about 11% [27].The fiber contents of the flour samples ranged from 0.17±0.02-8.00±0.00.African yam bean had the lowest fiber content and it was in agreement with that of Nwosu, [28] who reported that there were marked reductions of all fibre fractions on dehulling of all legume samples of African yam been studied. Fiber aids in lowering blood cholesterol, level and slows down the absorption of glucose, thereby keeping the blood glucose level in control [29]. It ensures smooth bowel movement and helps in easy flushing out of waste from the body, increase satiety and hence impact some degree of weight management. The carbohydrate composition range from 58.34±0.21-69.27±0.47.Millet has the highest value while African yam bean had the least .The values were desirable since carbohydrate is the source of calorie.

Table 2. Functional properties

S/N	WAC(g/ml)	LGC(g/ ml)	BULK-DENSITY(g/ml)
1	2.57^{h}±0.06	6.47^{g}±0.06	0.72^{fg}±0.01
2	2.17^{de}±0.06	6.27^{f}±0.06	0.66^{de}±0.05
3	2.10^{cd}±0.00	5.83^{ab}±0.06	0.56^{a}±0.25
4	2.33^{f}±0.06	6.07^{cd}±0.06	0.79^{h}±0.04
5	2.93^{j}±0.06	6.10^{de}±0.00	0.59^{abc}±0.04
6	2.23^{e}±0.06	5.97^{bcd}±0.06	0.62^{bcd}±0.00
7	1.97^{b}±0.06	6.87^{i}±0.06	0.59^{abc}±0.00
8	1.00^{a}±0.00	6.37^{fg}±0.05	0.63^{bcd}±0.00
9	2.43^{g}±0.06	6.67^{h}±0.05	0.62^{bcd}±0.00
10	2.37^{fg}±0.06	5.93^{bc}±0.05	0.63^{cde}±0.06
11	2.63^{h}±0.06	6.10^{de}±0.00	0.74^{g}±0.02
12	2.73^{i}±0.06	6.87^{i}±0.12	0.81^{h}±0.00
13	2.03^{bc}±0.06	5.87^{ab}±0.06	0.60^{abc}±0.02
14	2.67^{hi}±0.06	6.23^{ef}±0.05	0.58^{ab}±0.02
15	3.00^{j}±0.00	5.77^{a}±0.06	0.68^{ef}±0.00
16	2.60^{h}±0.10	10.23^{j}±0.25	0.82^{h}±0.02

All values are expressed as mean ± SD of three determinations. Values in the same column with the same superscript are not significantly different.

3.3 Sensory Analysis

The result of sensory results of the samples is shown in Table 3. The flours had appreciable ratings for colour, aroma, taste, texture and overall acceptability. However, the control sample which is whole wheat flour had the highest rating as compared with the other samples.

Table 3. Viscosity characteristics of the composite flours

S/n	Viscosity(mpa.s)
1	1.42^{b}±0.00
2	1.40^{b}±0.00
3	1.37^{b}±0.01
4	1.37^{b}±0.00
5	1.38^{b}±0.00
6	1.37^{b}±0.00
7	1.37^{b}±0.00
8	1.36^{b}±0.00
9	1.37^{b}±0.00
10	1.36^{b}±0.01
11	1.34^{b}±0.10
12	1.38^{b}±0.00
13	1.38^{b}±0.00
14	1.42^{b}±0.00
15	0.96^{a}±0.05
16	9.30^{c}±0.02

All values are expressed as mean ± SD of three determinations

3.3.1 Taste

Taste is an important sensory attribute of any food. The values for the taste ranged from 5.60±1.14-6.45±1.32 which differs from the control with mean score of 8.91±0.71. This observation may be attributed to personal choice or an influence of the experimental conditions [30,31], addition of high proportions of the flour samples in the composite flour may introduce objectionable characteristics which overwhelmed the traditional taste attribute of the pure wheat flour sample and affected the choice of their taste.

3.3.2 Colour

Colour is an important sensory attribute, which can enhance acceptability. It range from 4.25±1.88 - 6.85± 1.22 of which sample 3 had the highest while sample 5 had the lowest. The control numerically differed significantly with a mean score of 8.91±1.01.This observation may be attributed to the high content of amino acids in African yam bean and high content of sugars in cereal flours.

3.3.3 Texture

Food texture sometime embraces appearance [32]. The mean texture scores of samples ranged from 5.15±1.95- 6.80±0.91 while the control had 8.26± 1.01. The observation indicates that high supplementation of the flour showed moderate scores on texture. Sample 8 had the highest value while sample 7 had the lowest. The values obtained could be attributed to the absence of gluten in the flours.

3.3.4 Aroma

Aroma is an important parameter of food [23]. ‘Good’ aroma from food excites the taste buds, making the system ready to accept the product. ‘Poor’ aroma may cause outright rejection of food before they are tasted. The range is from 3.85±2.27- 5.70±1.56.But the control had a mean score of 7.80± 0.91.The degree of likeness of aroma decreased as the rate of African yam bean increased .The observation may be attributed to the beany aroma of processed African yam bean, it may also be attributed to the strangeness of the product. The beany flavour is commonly associated with food legumes [33]. African yam bean , enzymatic breakdown by lipoxygenases or autoxidation of linoleic and linolenic acid produces hydroperoxides such as ketones, aldehydes and alcohols that may be responsible for the beany flavour which discourages its consumption [34] [35,36].

Consumers attitudes may be tuned to accept new product if health claim, or social status is attached. In fact, there was the tendency for composite.

3.3.5 Acceptability

Both acceptance and preference are primarily economic concept. Acceptance of food varies with standards of living and cultural background, whereas preference refers to selection when presented with choice [23]. Preference is often influenced by prejudices, religious principles, group conformance, ‘status value’ and snobbery, in addition to the quality of the food. People have preferences, no matter how illogical they may appear. Therefore, the parameters are difficult parameters to determine in a new product development [37]. The range is from 5.45±1.39- 8.92±0.82 with the control (wheat flour) being the best rated, but from the composite flours sample

Table 4. Proximate composition of sorghum, millet and African yam bean

Parameters %	Sorghum	Millet	African yam bean
MOISTURE	8.03[b]±0.06	6.13[a]±0.15	8.46[c]±0.08
ASH	2.00[a]±0.00	4.67[b]±0.58	2.03[a]±0.06
FIBER	8.00[c]±0.00	6.10[b]±0.10	0.17[a]±0.02
FAT	5.47[a]±0.42	6.27[b]±0.46	8.61[c]±0.02
PROTEIN	10.13[b]±0.06	7.57[a]±0.28	21.84[c]±0.06
CARBOHYDRATE	66.33[b]±0.49	69.27[c]±0.47	58.34[a]±0.21

All values are expressed as mean ± SD of three determinations. Mean values within row with different superscripts are significantly different at ≤0.05.

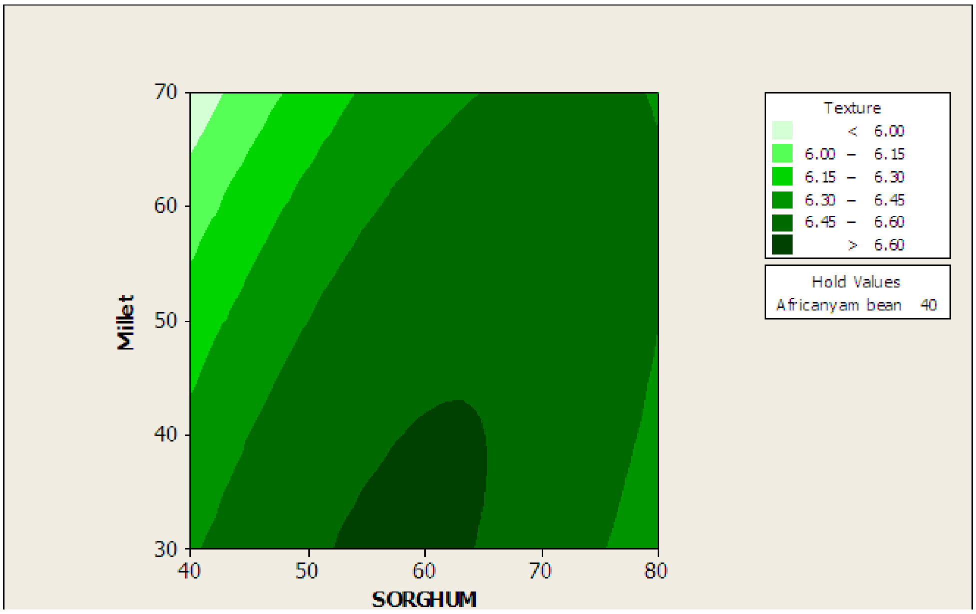

Fig. 4. Contour plot of texture: Millet Vs Sorghum

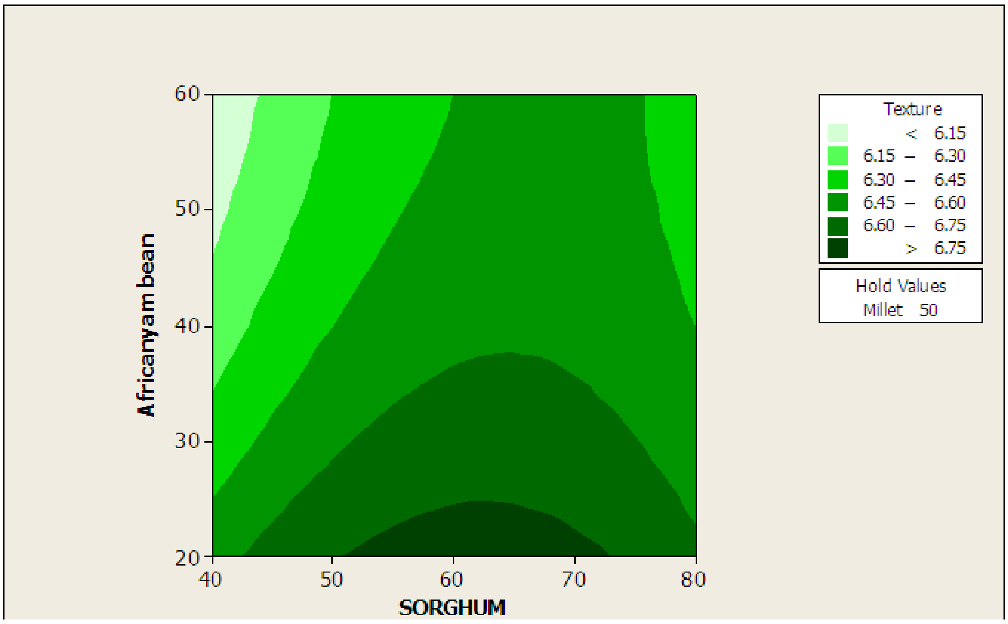

Fig. 5. Contour plot of texture: African yam bean Vs Sorghum

Table 4. Mean sensory scores of composite flours made from Sorghum, Millet and AYB

S/N	Taste	Colour	Texture	Aroma	Acceptability
1	5.60[a] ±1.14	5.30[abcd]±1.34	6.60[b]±0.75	3.85[a]±2.27	5.45[a] ±1.39
2	5.90[b] ±0.91	5.85[bcd]±1.22	6.35[b]±0.74	4.10[ab]±2.44	5.85[ab]±1.18
3	6.45[ab]±0.99	6.85[e]±1.22	6.45[b]±1.57	4.45[abc]±1.90	6.25[ab]±1.25
4	5.85[b]±1.31	5.65[bc]±1.59	6.30[b]±1.26	5.15[bc]±1.49	5.70[ab]±1.42
5	6.10[b]±0.97	4.25[a]±1.88	6.65[b]±0.75	5.40[bc]±1.50	5.70[ab]±1.17
6	6.05[b]±1.09	5.50[bc]±1.64	6.65[b]±1.09	4.40[abc]±1.76	5.65[ab]±1.18
7	6.45[b]±1.32	6.25[cde]±1.37	5.15[a]±1.95	5.05[abc]±1.36	5.90[ab]±1.07
8	6.10[b]±0.79	5.65[bc]±1.42	6.80[b]±0.69	4.90[abc]±1.74	6.05[ab]±1.05
9	6.15[b]±1.14	5.40[bc]±1.60	6.35[b]±0.99	5.60[c]±1.43	6.10[ab]±1.16
10	6.50[b]±1.19	6.35[de]±1.26	6.55[b]±0.83	5.35[bc]±1.39	6.45[b]±0.83
11	5.85[b]±1.31	5.55[bc]±1.32	6.35[b]±1.14	5.20[bc]±1.51	5.65[ab]±1.66
12	6.10[b]±1.21	5.80[bc]±1.47	6.60[b]±1.05	5.70[c]±1.56	6.05[ab]±0.99
13	5.85[b]±1.53	5.30[bc]±1.78	6.70[b]±1.22	4.95[abc]±1.99	5.85[ab]±1.39
14	5.90[b]±1.29	5.15[bc]±1.46	6.45[b]±1.15	5.25[bc]±1.99	5.90[ab]±1.12
15	5.90[b]± 1.41	4.85[abc]±1.57	6.35[b]±0.88	5.45[c]±1.50	5.70[ab]±1.03
16	8.91[a]± 0.71	8.26[e]±1.01	7.91[bc]±1.23	7.80[b]±0.91	8.92[a]±0.82

Values are mean scores ±SD. The values in the same column with the same superscript are not significantly different. 1= 60:50:60 (Sorghum, millet and AYB) respectively 7=40:70:60 13=60:70:40; 2= 80:70:60 8= 60:50:20 14=60:30:40; 3=40:50:40 9= 80:50:40 15=40:30:20; 4=60:50:40 10=40:70:20 16=wheat flour; 5=80:30:20 11=80:30:60; 6=40:30:60 12=80:70:20

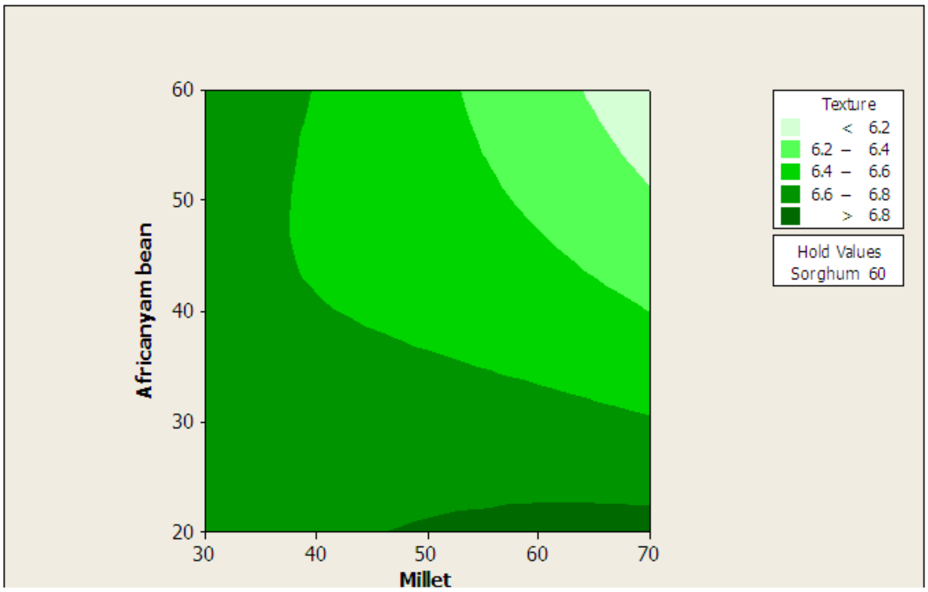

Fig. 6. Contour plot of texture: African yam bean Vs Millet

10 was the most acceptable with the value of 6.45±0.83.

The mixture of the components as shown in red ink (Fig 7) would yield the blend whose texture will be like highly (6.904) as indicated in the optimization plot.

The relationship between the response variable (texture) and the mixture components is represented in a model form. The regression equation is full quadratic as presented in equations 1 and 2.

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X^2_1 + b_{22}X^2_2 + b_{33}X^2 + b_{12}X_{12} + b_{13}X_{13} + b_{23}X_{23} \quad (1)$$

$$Y = 5.27 + 0.048X1 + 0.005X2 - 0.008X3 - 0.00058X^2_1 - 0.00014X^2_2 + 0.00017X^2_3 + 0.0039X_{12} + 0.00017X_{13} \quad \text{Eqn. (2)}$$

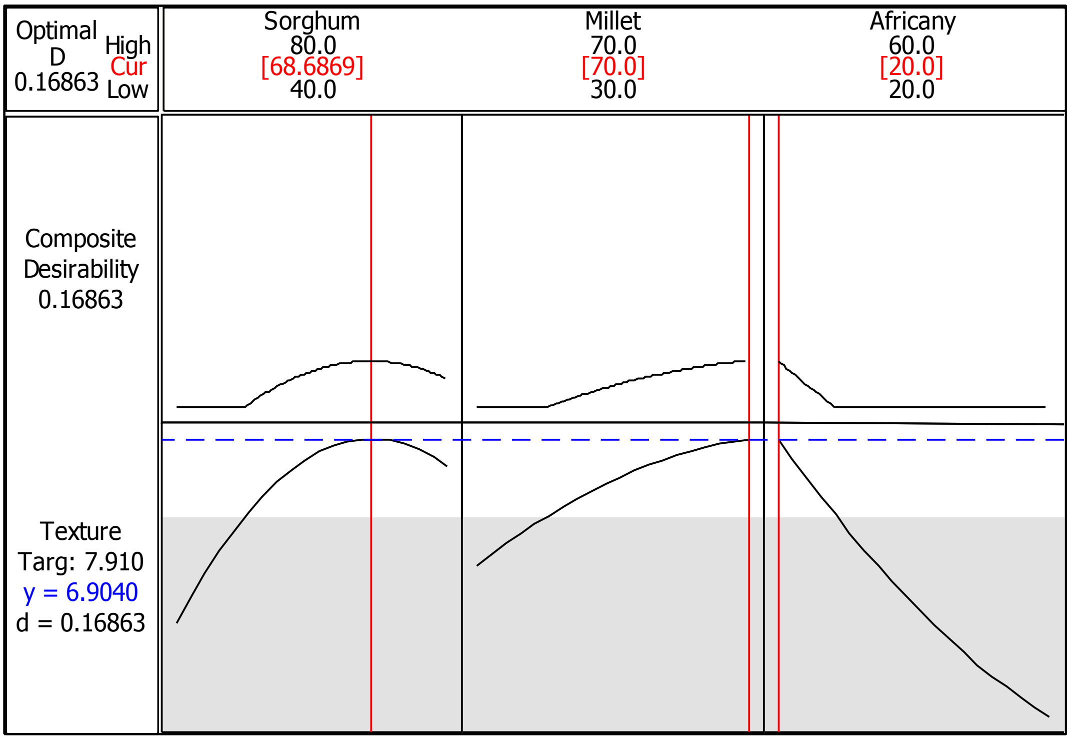

Fig. 7. Optimization plot for texture

4. CONCLUSION

This study revealed the functional and sensory variations that exist in samples of composite Sorghum, Millet, and African yam bean flours. The variations in texture of the blends was observed to be slightly different from each other which is as a result of carbohydrate contents of the original samples used for the formulation of the blends. However, the work has shown that the Central composite design (face centered) methodology could be use to determine the effect of variations on sensory scores of flour blends containing sorghum, millet, and African yam bean. This research also showed that the modeling of experimental data by optimization could be used to predict a blend of moderately acceptable texture without preparing samples which will be useful in the production industries. The technique employed in this study can be used to develop a novel food.

5. RECOMMENDATION

From the study, it was observed that sample 8 had the highest rating for texture as compared with other samples in the sensory evaluation while the optimization done showed sample 2 to yield best acceptable texture. This is as a result of high protein content of African yam bean and also the high carbohydrate content of Millet. However, the two blends (sample 2 and 8) is adviced to be adopted for commercial purposes since a better texture improves appearance and acceptability among consumers.

It is advised that best choices be made on proximate composition and not just on individual preferences and personal choices. Also African yam bean should be used to fortify conventional flours which are low in protein.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sena-Saldivar S. Cereal Grains: Properties, processing and Nutrional Attributes, CBS publishers and distributors India. 2010;535.
2. Lantican RM. The science and practice of crop production. UPLB, College, *Los Brios* Languna. 2001;4-5.
3. Faber M, Jogesser VB, Benade AJS. Nutritional status and dietary intakes of children aged 2 – 5 years and their caregivers in a rural South African community. International Journal of Food Science and Nutrition. 2011;52(1):401 – 411.
4. Onesmo NO. Effects of malting and fermentation on the composition and functionality of sorghum flour. Dissertations & Theses in Food Science and Technology;2011.
5. Thilagavathi T, Banumath P, Kanchana S, Ilamaran M. Effect of heat moisture treatment on functional and phytochemical properties of native and modified millet flours. Plant Archives. 2015;15(1):15-21.
6. Food and Agriculture Organisation. Crops statistics-concepts, definition and classifications; 2010.
7. Akande SA. Germ plasm Characteristic of African Yam Bean (*Sphenostylis stenocarpa*). South-West, Nigeria. 2009; 154(2):25-29.
8. Gouri MR, Poongadi VT. Characterisation and glycemic load of ready to cook prebiotic flour mixture. International Journal of science and Nature. 2013;4(4): 591-597.
9. Fasasi OS. Proximate antinutrional factors and functional properties of processed pearl millet. Journal of food technology. 2009;7(3):92-97.
10. Ojukwu M, Olawumi IA, Ibeabuchi C, Amandikwa C. Physical, proximate and functional properties of 'Nsama' A local variety of African yam bean (*sphenostylis stenocarpa*) grown in southern states of Nigeria. African Journal of Food Science and Technology. 2012;3(10):260-267.
11. Majzoobi M, Abedi E. Effects of pH changes on functional properties of native and acetylated wheat gluten. International Food Research Journal. 2014;21(3):1183-1188.
12. Onwuka GI. Food analysis and instrumentation theory and practice, Napthali Press, Lagos. 2005;15-170.
13. AOAC. Official Methods of Analysis (AOAC) International 18TH ed Maryland;2005.
14. AOAC. Official methods of analysis (AOAC) International 7th ed. Gathershurg M.D; 2010.
15. Oyeyinka SA, Oyeyinka AT, Karim OR, Toyeeb KA, Olatunde SJ. Biscuit making potentials of flours from wheat and plantain at different stages of ripeness. Croat J Food Sci Technol. 2014;6:36-42.
16. Badifu GI, Akubor PI. Influence of pH and sodium chloride on selected functional and physical properties of African breadfruit. (*Treculia africana* Decne) kernel flour. Plant Foods for Human Nutrition. 2001; 56(2):105-150.
17. Igbabul BD, Bello FA, Ani EC. Effect of fermentation on the proximate composition and functional properties of defatted coconut (*Cocos nucifera L.)* flour. Sky Journal of Food Science. 2014;3(5):030-040.
18. Nibia IC, Bokanga MG, Jackson FI, Schliane DS, Li BW. Physicochemical properties and starch granular characteristics of flour from various *manihot esculenta* (cassava) genotypes. Journal of Food Science. 2001;67(1):1701-1705.
19. Folasade MM, Ayobami OE. Evaluation of nutritional composition, functional and pasting properties of wheat flour-coconut flour blends. Croat. J. Food Sci. Technol. 2019;11(1).
20. Suresh C. Samsher S, Durvesh K. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology. 2015;52(6): 3681-3688.
21. Onimawo IA, Akubor P. Food chemistry: Integrated Aprroach with Biochemical Background. Ambik Press Ltd, Benin City, Nigeria. 2005;158-162
22. Carr RL. Powders and granules properties and mechanism. In: Gas-Solids processing Industries. John Wiley and Sons, New York.1976;175-182.
23. Iwe MO. Handbook of sensory methods and analysis. Projoint Communications Services Ltd, Enugu. 70-72.
24. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. Macmillian publication London. 1985;283-285.

25. Codex-Alimentarius 2016.Standard for wheat. International Food Standards, WHO-FAO, Codex Stan.1995;152-1985.
26. Eromosele CO, Arogundade LA, Eromosele IC, Ademuyiwa O. Extractability of African Yam Bean protein in acid, salt and alkaline aqueous media. Food Hydrocolloids. 2008;2(8):1622-1628.
27. Omah EC, Okafor GI. Selected functional properties, proximate composition of flours and sensory characteristics of cookies from wheat and millet-pigeon pea flour blends. Pakistan Journal of Nutrition. 2015;14(9):581-585
28. Nwosu JN. Evaluation of the proximate Composition and Antinutritional Properties of African Yam Bean(*sphenostylis sternocarpa*) using malting treatment. International Journal of Basic and Applied Sciences. 2013;2(4):157-169.
29. Anderson JW, Baird P, Richard H. Health benefits of dietary fibre. Particulate properties and reheology of pregelled yam (*D. Rotundata*) products. Journal of Food Technology. 2009;41(3):180-182.
30. Janet J. and Nyla, T. Eating qualities of muffins prepared with10% and 20% soy flour. Journal of Nutrition Recipe Menu Development,2001;3(2);25-33.
31. Dendy DA. Review of composite flour technology in the context of Tanzania. National Resources Institute, Chatham, UK. 2013;1-23.
32. Eduardo M, Svanberg U, Oliveira J, Ahrne L. Effect of cassava flour characteristics on properties of cassava-wheat-maize composite bread types. International Journal of Food Science. 2013;1(1):1-10.
33. Okoye JI, Okaka JC. Production and evaluation of protein quality of bread from wheat cowpea flour blends. Journal of Food Science and Technology. 2009;3(1): 1-7.
34. Mannay S, Shadaksharaswany CM. Foods: Facts and Principles. (2nd ed.). New Age International Ltd. Publishers. New Delhi, India. 2005;126-200.
35. Awadelkareem AM, Mustafa AI, Tinay AH. Protein, mineral content and amino acid profile of sorghum flour as influenced by soybean protein concentrate supplementation. Pakistan Journal of Nutrion. 2008;7:475-479.
36. Serrem C, Kock H, Taylor J. Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. International Journal of Food Science and Technology. 2011;46(2):74-83.
37. Sim J, Nya T. Eating qualities of muffins prepared with 10% and 30% soy flour. Journal of Nutrition Recipe Menu Dev. 2001;3(2):10-27.

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