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Quality Characteristics of Complementary Food from Locally Fermented Maize Flour Blended with Sprouted Velvet Bean *(Mucuna utilis)* Flour in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AOAO, TJB and COI conceived the idea. Authors AOAO, TJB, COI and OJC designed the analyses. Authors TJB and COI performed the experiments under the supervision of authors AOAO and OPO. Authors TJB, COI, OJC and AOAO performed data analysis while authors TJB, COI, AOAO, OPO and OJC performed the manuscript writing. All authors read and approved the final manuscript.

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ABSTRACT

Complementary food produced from fermented maize and sprouted velvet bean flour in ratios 90:10, 80:20, 70:30, 60:40, 50:50 and 100% maize (control) was studied in this research work. Proximate composition, anti-nutritional and sensory properties of the blends was evaluated using standard analytical methods. Results showed that moisture (5.49% - 8.35%), ash (0.55% - 1.25%), crude fiber (3.50% - 4.98%), protein (8.05 -13.05%) increased with increased velvet bean flour while carbohydrate content decreased (77.37% - 63.48%). Phytate (2.11 - 2.34 mg/100 g) and oxalate (0.40–10.1 mg/100 g) are within lethal doses. The colour, taste, and mouth-feel of the sample with 10% velvet bean flours were significantly ($p<0.05$) being the most acceptable by the assessors. This study showed that protein-energy malnutrition in developing nations could be alleviated with complementary foods.

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1. INTRODUCTION

Presently, about 800 million malnourished people exist in most under-developed countries of the world [1], and in developing countries like Nigeria where population growth is not controlled and their diet is basically cereal-based foods. The undernourished and elderly are the categories of people that are mostly affected. They require more nutrients such as amino acids, fatty acids etc. which forms the basis for enrichment of *ogi* flour with sprouted velvet bean (*Mucuna utilis)* flour, a legume underexploited due to its anti-nutrient content assumed significantly to improve and elevate protein requirement of undernourished population.

Fermented maize *(Ogi)* is a fermented gruel food in Nigeria made from maize, sorghum and millet. This gruel food is known to have a distinctive sour taste due to the production of lactic acid during fermentation that makes people crave it. It is affordable, easy to prepare and cheap (FAO, 2006). Fermented maize gruel is a popular breakfast meal recommended for growing children but few people can also take it anytime of the day. Gelatinized *ogi* is commonly referred to as pap with local names such as *eko, agidi, akamu* among others. Also, fermented *ogi* food produced from sorghum is usually called ogi-*baba by* consumer in southern part of Nigeria. It is usually eaten with *moinmoin*, fried plantain, *akara*, milk, and occasionally with vegetable.

Velvet bean (*Mucuna utilis)* belongs to the legume family, under-utilized specie found majorly in Africa and parts of the America and Asia [2]. Velvet bean have been reported to be rich in protein with certain essential amino acids and fatty acids especially palmitic and linoleic acids lipid [3]. Velvet bean (*Mucuna utilis)* when roasted can be used as a replacement for coffee especially in Central and in some parts of Southern America where hairs on the seed pods have found usefulness as skin irritant known as 'cowitch' [2]. Moreover, these raw seeds may inhibit the absorption of other nutrients which may have detrimental effects on living systems as they contain substances such as lecithin and saponin that may affect gastrointestinal tract lining.

Sprouting is a form of controlled germination involving soaking of seeds in water which gives rise to the formation of a protrusion. At the end of the process, the seeds are consumed as a food product with less digestible properties. Hailu and Addis [4] also reported that sprouting may be useful in the conversion of indigestible part of seeds to digestible form which could improve the bioavailability of nutrient in the seed. Sprouting processes have also been reported to enhance the presence of zinc, calcium, and iron in the body during digestion but reduces the availability of tannin and phenol levels which largely depend on soaking and sprouting periods as well as concentration and pH [5]. Sprouting otherwise known as germination has been known to help improve the nutritional composition and reduce anti-nutrients present in various beans of which velvet bean (*Mucuna utilis)* is inclusive thereby making the *ogi* flour more nutritious.

Therefore, this study was carried out to investigate nutritional, anti-nutritional, physicochemical and sensory properties of *ogi* flour obtained from blends of fermented maize (*Zea mays*) and sprouted velvet bean (*Mucuna utilis)* flour.

2. MATERIALS AND METHODS

2.1 Materials

Mature, wholesome, disease-free grains (maize) and other raw materials were obtained locally from Yaba main market while mature and dry seeds of velvet bean were sourced from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

2.2 Methods

2.2.1 Production of fermented maize flour

Fermented flour from maize seeds were produced using modified method of Ojo and Enujiugha, [6]. This method involves steeping maize seeds in water for 48 hours in order to soften the seeds which is followed by milling using attrition mill and then sieved to separate germ from the hull. The germ was then mixed with little water to obtain *ogi* slurry and this mixture was then fermented anaerobically for a period of 72 hours. The fermented maize cake was obtained by pressing the fermented meal and drying in oven at 60°C. The content was then milled with attrition mill and sieved with 0.5 µm mesh size and stored in sterile polythene bags until needed for combination with sprouted mucuna beans flour and further analysis.

2.2.2 Production of sprouted *Mucuna utilis* flour

Sprouted flour from velvet bean seeds were produced by modified method of Mugendi et al. [7]. Dried mature velvet beans were sorted out to remove some infested seeds, which is followed by cracking and winnowing to remove the seed coat. Then, velvet bean seeds were sterilized for 1min in ethanol followed by soaking in distilled water for 24 hours. The seeds were drained from water and spread on a tray and allowed to undergo germination for 72 hours in the dark. Seed coat of germinated seeds was remove manually and the seeds were dried at 60°C in the oven for 24 hours, milled into flour using attrition mill and sieved with 0.5 µm mesh size and stored in sterile polythene bags until needed for analysis.

2.2.3 Preparation of composite blends

The blends for the complementary food formulation was prepared by mixing fermented maize flour (90, 80, 70, 60 and 50%) with 0, 10, 20, 30, 40, and 50% of mucuna bean flour as shown in Table 1.

2.3 Chemical Analysis

2.3.1 Proximate composition

Determination of moisture content: The procedure used for analysis of moisture was described by method of AOAC [8]. Two grams of each flour sample was weighed into dried weighed petri dishes. The samples were placed in a moisture oven at 105^{o}C and heated for 3 hours. The dried samples were cooled in a desiccator and weighed. The moisture content was then calculated by using the equation given below.

Percentage moisture content Ξ (Change in weight / Weight of food sample before drying) x 100

Determination of ash content: The procedure used for analysis of ash was described by method of AOAC [8]. Two grams of samples were dispensed into clean already weighed crucibles and placed in a pre-heated muffle furnace (Carbolite, ELF11/14B, S336RB) England and the content was then incinerated at 600°C until turn white and free of carbon. The sample was then removed, cooled in a desiccator and weighed again. The weight of the residual ash content was then calculated as:

Ash content = (Weight of Ash / Weight of sample) x 100

Determination of fat content: Two grams of each flour sample was wrapped with filter paper and placed in a clean, dried and weighed fat extraction thimble fitted to a clean round bottom flask. The flask contained 120 ml of petroleum ether with content heated over a heating mantle for 5 hours. After extraction, the solvent was evaporated at 105°C for 2 hours, cooled and weighed for fat content estimation. The difference in weight was taken as mass of fat and expressed in percentage of the sample.

Fat content (%) = (Weight of fat extracted / Weight of food sample) x 100

Determination of crude fiber content: Two grams (2 g) of each flour sample was dispensed into a flask with the addition of 100 mL of Trichloroacetic acid which was then boiled for 40 min before refluxing. The content was cooled, filtered and the residue was washed and dried in oven at 105^{o}C to a constant weight. The dried sample was removed, cooled and weighed. The difference in weight is recorded as the fibre and expressed in percentage

$$\% \text{ Crude fibre} = ((W_1 – W_2) / W_0) \times 100$$

Where;

W_0 = weight of original sample,
W_1 = weight of sample before incineration,
W_2 = weight of sample after incineration

Determination of crude protein: Protein content of the flour sample was estimated by the method described by AOAC [8]. Concentrated sulphuric acid (H_2SO_4) was used in the digestion of the samples by heating the content in the presence of digestion mixture. The content was then made alkaline with the formation of Ammonium sulphate, the ammonia produced was collected in 2% solution of boric acid. The content was then titrated against standard HCl to give the nitrogen present in the sample. The percentage protein content was estimated by multiplying 6.25 with nitrogen value obtained as given by formula given below.

Table 1. Blends of maize flour and mucuna bean flour

Sample		Maize flour	Mucuna bean flour
Sample 1	100% Maize flour	100%	0
Sample 2	90%:10% mucuna bean	90	10
Sample 3	80%: 20% mucuna bean	80	20
Sample 4	70%: 30% mucuna bean	70	30
Sample 5	60%: 40% mucuna bean	60	40
Sample 6	50%: 50% mucuna bean	50	50

% N = ((Sample titration reading – Blank titration reading) N x 0.014 x Dilution of sample)) / Weight of sample

% Crude Protein = 6.25 * x % N

Determination of carbohydrate content: Carbohydrate content of the composite flour sample was estimated by AOAC [8]. The carbohydrate is evaluated by difference in which the sum of percentage values of other proximate parameters was subtracted from 100%.

2.3.2 Functional properties of composite flour

Determination of water absorption capacity: The method described by AOAC [8] was adopted for determination of water absorption capacity. Two grams (2 g) of flour sample was dispersed into 20 ml distilled water contained in a centrifuged bottle and the content was allowed to stand for 30 min, this was then followed by centrifugation at 2,000 rpm for 30 min. The decanted supernatant was discarded and the tube and its contents weighed as water absorbed per g of sample. The water absorption capacity represents the gain in mass of water.

Determination of swelling power: One gram (1 g) of the sample was dispensed into a pre-weighed graduated centrifuge tube. Distilled water was mixed with the flour to make up to 10 ml of dispersion and the content stirred and then heated in a water bath for 1 hour with agitation to ensure until gelatinization occur. The sample was then centrifuged after cooling and the supernatant dispensed into petri dish and weighed after drying for 1 hour. The dried samples were weighed and recorded as described by Hirsch and Kokoni [9].

2.3.3 Physicochemical properties of composite flour

Determination of pH value of flour: Twenty grams (20 g) composite flour samples were mixed were 50 ml distilled water with constant stirring for 10 min. The stirring was done to prevent the starch from coating the glass electrodes and to obtain reproducible results. The pH value was then measured using pH meter (JENWAY PHS-25) and buffer 4.0 and 7.0 were used to standardize the meter.

Determination of titratable acidity: Five grams (5 g) of composite flour samples were dissolved into distilled water in a flask and made up to 50 ml mark. Five (5.0 ml) aliquot of the sample solution was taken and titrated against 0.1 N sodium hydroxide (NaOH) using phenolphthalein solution as indicator. Titratable acidity was calculated as percentage tartaric acid [8].

% tartaric acid = (Volume of 0.1 M NaOH used x 0.09 x 100) / Weight of the sample

2.3.4 Anti-nutritional content of sample

Determination of phytic acid: Spectrophotometric method adopted by Pearson (1976) was used for the phytic acid content. About 5 g of the flour was mixed with 20 ml of 0.3 N HCl in a beaker with continuous stirring on bursen flame. The content was then filtered made up to 100 ml mark of the volumetric flask.

Determination of oxalate content: Oxalate content was determined by modified method of Day and Underwood (1986) as described by Olawoye and Gbadamosi [10]. One (1.0 g) flour was mixed with 75 ml of 1.5 M H_2SO_4 in a flask with continuous stirring and then filtered. This is followed by titrating 25 ml of the filtrate against 0.05 M KMnO4 solution until a faint pink colour is produced. The oxalate was calculated as the sodium oxalate equivalent.

Determination of tannin content: The modified method described by Ogunlakin et al. [11] was adopted for tannin content evaluation. One gram (1 g) of composite flour samples were mixed with 20 ml of methanol in a beaker. The content was then in a dropped in a water bath for 1 hour with continuous stirring. The extract was filtered and rinsed with methanol and then mixed with distilled water. Distilled water was added to 1 ml of sample extract to make up 20 ml dispersion in a flask. This is followed by addition of 2.5 ml of Folin-Denis reagent and 10 ml of 17% Na_2C0_3 with continuous agitation. The content was mixed with distilled water and allowed to stand until a bluish-green colour persisted. The absorbance of the tannic acid standard solutions and samples were taken after the standard tannic acid was treated with 1 ml of the sample at a wavelength of 760 nm using Spectronic 21D Spectrophotometer.

2.3.5 Pasting properties of the samples

Pasting characteristics of composite flour were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+Newport Scientific RVA). Starch suspension prepared from the mixture of the composite flour and distilled water was poured into the sample canister of RVA machine. A paddle was positioned into the canister and then put down in the RVA machine. The starch was heated at temperature of 50 to 95°C in 2 min, and cooled back to 50°C within 2 min. The starch temperature was finally heated at 50^oC for 1 min at the end of the experiment with each cycle lasting for 12 min. The experiment was carried out in duplicates and the mean values reported.

2.3.6 Amino acid profile analysis

The amino acid profile of the flour from blends of maize and sprouted velvet bean were evaluated by the method adopted by Mashair et al. [12]. The composite flour samples were digested using 6 N HCl for 24 hours followed by running the flour samples on the Beckman Amino Acid Analyzer (Model 6300, Beckman Coulter Inc., Fullerton, Calif., USA) using ninhydrin derivatization method with sodium citrate as buffers while cysteine and methionine contents of the flour samples were evaluated with the oxidation of performic acid; tryptophan content of the flour samples was determined by modified method adopted by Pianesso et al. [13]. Each amino acid content was calculated as mg/100 g crude protein of flour sample.

2.3.7 Sensory evaluation

Acceptability of porridge was carried out by homogenizing one hundred grams (100 g) of each flour with 500 ml distilled water. The slurry was heated for about 15 min with constant stirring. This is followed by the addition of sugar to taste and the content kept for evaluation using 20 untrained panelists comprising undergraduate students of Yaba College of Technology, who were asked to score the overall acceptability using a nine-point hedonic scale ranging from 1 (Disliked extremely) to 9 (Like extremely).

2.3.8 Statistical analysis

Data obtained from all the parameters evaluated were recorded in triplicate and subjected to analysis of variance (ANOVA) and differences of mean value separated by Duncan's multiple range tests at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Maize Flour Supplemented with Sprouted Velvet Bean Flour

Flour samples were produced from different blends of fermented maize and sprouted mucuna bean flour. The results of the proximate composition of blends are indicated in Table 2. Flour produced from different blends had moisture content of 6.70%, 7.38%, 8.35%, 9.21% and 9.75% for Samples 2, 3, 4, 5 and 6 respectively while Sample 1 had 5.4% moisture level. Food product in flour form should not contain more than 12% moisture content level; however, 10% moisture level is acceptable baseline for flour. The low moisture content observed in all the samples will result into longer shelf life and good keeping quality of the samples [14]. Also, high moisture level in flour sample may lead to increased rate of spoilage hence, reduced shelf life and this is in line with the findings of Otunola et al. [15].

In terms of protein content, Sample 6 exhibited high protein content of 13.05% with Sample 1 displaying the least protein content of 8.05%. However, there was significant difference in moisture and protein content of the blends. The high level of protein in the flour is due to the presence of protein rich mucuna bean seeds that may have contributed to the increased protein content as confirmed by Adeboye and Phillips [16]. Studies have shown that protein quality improved in cereal-legume blends due to contribution of lysine by legume and methionine by cereal [17].

The ash content ranged from 0.55% to 1.45%, which is in agreement with report given by Jimoh and Olatidoye [18] and Adebayo-Oyetoro et al. [19] on complementary feeding for infants. This is because ash content makes up the total mineral content in food and may therefore serve as a useful means of evaluating nutritional quality of foods [20]. The fiber content of the flour samples tends to increase as the velvet bean flour inclusion increased. This ranged from 3.50-4.98% with sample 1 and 6 having the least and highest values respectively. The values obtained were in agreement with the standard of 5 g/100 g stated by FAO [21]. Also, dietary fiber is made up of indigestible complex carbohydrate which is important in the digestion of food and maintenance of intestinal tract [22]. Fat content ranged from 5.29% to 6.48% and significant differences exist among all the blends obtained. Similar results were also given by the reports of Mbata et al. [23] and Otunola et al. [15]. Fat has been reported to be useful and important in the absorption the fat-soluble vitamins and essential fatty acids in the body. The carbohydrate level of composite flour varied between 63.48% and 77.37% with Sample 1 (77.37%) displaying the highest carbohydrate content and Sample 6 (63.48%) showing the lowest value. This affirmed the claims of other research workers [24,18,19].

3.2 Functional Properties of Maize Flour Supplemented with Sprouted Velvet Bean Flour

Table 3 indicates the functional properties of fermented maize-mucuna flour blends. The results revealed that significant differences exist among the samples at $p<0.05$. An increase in the content of water absorption capacity in the Sample 1 was observed with value of (2.67%) while Sample 6 had the least value of 2.25%. The higher the water absorption capacity, the higher the digestibility of the starch, and this may enhance the ability of the flour to associate with water under a limiting condition so as to enhance the handling process [25]. Water absorption capacity (WAC) is a property that describes the tendency of flour to absorb water during processing. It is also an important property which can be used to determine if the flour can be employed in food formulations. The higher water absorption capacity value obtained may give an indication that mucuna bean flours could be used in confectionary products. Sample were significantly different ($p<0.05$) in the values of swelling capacity. Sample 1 had the highest value of swelling capacity. Similar reports have been given by Adebowale et al. (2005) on the use of mucuna bean flour as a food thickener.

3.3 Physicochemical Properties of Maize Flour Supplemented with Sprouted Velvet Bean Flour

The physicochemical property of the sample presented in Table 4 indicated that significant differences exist in the titratable acidity (TTA) and pH values of the composite flour samples at $p<0.05$. The TTA had a direct relationship with the velvet bean flour, the TTA increased as the velvet bean flour inclusion increased. Sample 1 exhibited the least value (0.50 g/L) while Sample 6 had the highest value of 1.52 g/L. Meanwhile, pH value varied between 6.04 and 6.28 with an inverse relationship with the velvet bean flour inclusion increased; sample 6 had the lowest pH value. These values obtained were similar to that reported by Edema et al. [24] as the value ranges from 6.0-7.0.

3.4 Antinutritional Content of Maize Flour Supplemented with Sprouted Velvet Bean Flour

Table 5 shows the results of the antinutrient composition of porridges produced from maize-mucuna flour blends. Tannin content of the samples revealed that Sample 6 has the highest tannin content of 1.21 mg/100 g which is relatively low and may be of little significance. Tannin is known to bind protein and digestive enzymes which may bring about a reduction in protein level. Tannin has been reported to contribute to interference of iron absorption [26] and according to Pikuda and Ilelaboye [27], the lethal dose of tannin is 0.7 - 0.9 mg/100 g. Oxalate content of composite flour blends ranged between 0.4, 5.09, 8.05; 9.10; 9.45; and 9.18 for Samples 1, 2, 3, 4, 5 and 6 respectively. The results from this study gave an indication that tannin and phytic acids are very stable to heat. Hui et al. (2000) gave a safe value of 0-5 mg/100 g for oxalates. Tannin structures have been reported to be complex in nature and the strong electrostatic force may determine the degree of heat damage to these compounds during heat processing [27] that will bring the amount to safe level.

3.5 Pasting Properties of Composite Flour from Maize-Velvet Bean Blends

Pasting properties of fermented maize-sprouted velvet bean blends are presented in Table 6. The pasting property is used to predict the behaviour of porridge during and after cooking. The result shows that peak viscosity (2508-2120 RVU) with the Sample 1 exhibiting highest peak viscosity value, lowest value was recorded in Sample 6. Peak viscosity is the highest viscosity that can be attained by flour when is applied to the flour in RVU. Trough value ranged from 1661 to 1598 RVU in substituted maize flour and un-substituted maize flour respectively. Breakdown viscosity ranged from 874.5 to 650.8 RVU; final viscosity value varied from 2307 to 2268.4 RVU. Setback viscosity value varied from 673.5 to 615.5 RVU. Also, peak time varied from 4.9 min to 5.7 min. Pasting temperature value ranged from 77.85°C to 77.95°C. Pasting temperature of the flour sample in this study is far less than 100°C which is known to the boiling point of water indicating that the flour can form a thick gel below the boiling point. This may bring about a remarkable cost saving in terms of energy usage at a commercial level. Viscosity has been reported to be dependent on amylopectin fraction of carbohydrate molecules interaction [28]. Peak viscosity gives useful information on the behaviour of starch in flour samples and composite flour mixture so as to obtain useful starch paste [29]. Final viscosity gives an indication of the ability of flour samples to form gel when subjected to thermal heat process (cooking). Hence, final viscosity (2307 RVU) value of Sample 1 is an indication that the flour has the tendency to form a thick gel due to coming together of (bonding) starch molecules [30]. Similar findings were reported by Jimoh and Olatidoye [18] on blends of yam-soybean flour samples. Also, Adebayo-Oyetoro et al. [19] gave a similar report of the study on fermented sorghum-walnut flour blends. Set back gives an indication that cooked flour be hardened when cooled and high set back is commonly used for quality checks which may be due to high leaching of amylose. Composite flour blends from maize and mucuna bean exhibited low breakdown values which indicated high stability of maize-mucuna flour blends [31].

3.6 Composition of Amino Acid of Fermented Maize Flour Supplemented with Sprouted Velvet Bean Flour

The result in Table 7 gives information about the composition amino acid of fermented maize flour supplemented with sprouted velvet bean flour showing the presence of eighteen amino acids.

Table 2. Proximate composition of fermented maize-sprouted mucuna flour blends

Samples	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Carbohydrates (%)
Sample 1	$5.49^{e}\pm0.02$	$8.05^{f}\pm0.05$	$5.29^{b}\pm0.01$	$3.50^{c}\pm0.05$	$0.55^{d}\pm0.05$	$77.37^{a}\pm0.03$
Sample 2	$6.70^{d}\pm0.05$	$9.28^{e}\pm0.02$	$6.03^{a}\pm0.02$	$4.95^{b}\pm0.05$	$0.63^{c}\pm0.03$	$72.42^{b}\pm0.02$
Sample 3	$7.38^{c}\pm0.02$	$10.47^{d}\pm0.03$	$6.01^{a}\pm0.01$	$4.67^{bc}\pm0.03$	$0.80^{b}\pm0.05$	$70.69^{c}\pm0.01$
Sample 4	$8.35^{b}\pm0.05$	$11.64^{c}\pm0.04$	$5.38^{b}\pm0.02$	$4.98^{b}\pm0.02$	$1.25^{a}\pm0.05$	$68.40^{d}\pm0.05$
Sample 5	$9.21^{a}\pm0.05$	$12.85^{b}\pm0.05$	$6.41^{a}\pm0.02$	$5.24^{a}\pm0.01$	$1.38^{a}\pm0.01$	$64.91^{e}\pm0.02$
Sample 6	$9.75^{a}\pm0.05$	$13.05^{a}\pm0.02$	$6.48^{a}\pm0.02$	$5.49^{a}\pm0.04$	$1.45^{a}\pm0.04$	$63.48^{f}\pm0.05$

Mean values with different superscripts within the same column are significantly different at 5% level. Sample 1- 100% locally fermented maize flour, Sample 2-90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4-70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6-50% sprouted mucuna flour and 50% maize flour

Table 3. Functional properties of fermented maize-sprouted mucuna flour blends

Samples	Water absorption capacity (%)	Swelling power (g/g)
Sample 1	$2.67^{a}\pm0.02$	$9.67^{a}\pm0.02$
Sample 2	$2.42^{c}\pm0.02$	$7.23^{b}\pm0.01$
Sample 3	$2.45^{c}\pm0.05$	$6.11^{c}\pm0.01$
Sample 4	$2.52^{b}\pm0.02$	$4.32^{d}\pm0.05$
Sample 5	$2.44^{d}\pm0.01$	$4.25^{e}\pm0.04$
Sample 6	$2.25^{e}\pm0.04$	$3.22^{f}\pm0.05$

Mean values with different superscripts within the same column are significantly different at 5% level. Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4-70% sprouted mucuna flour and 30% maize flour, Sample 5-60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

Table 4. Physicochemical properties of fermented maize-sprouted mucuna flour blends

Samples	Titratable acidity (g/L)	pH
Sample 1	0.50^{f}±0.03	6.21^{b}±0.01
Sample 2	0.77^{d}±0.03	6.95^{a}±0.05
Sample 3	0.59^{e}±0.01	6.97^{a}±0.03
Sample 4	1.08^{c}±0.02	6.04^{b}±.02
Sample 5	1.25^{b}±0.05	6.28^{b}±0.04
Sample 6	1.52^{a}±0.04	6.08^{b}±0.02

Mean values with different superscripts within the same column are significantly different at 5% level. Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

Table 5. Antinutritional content of fermented maize-sprouted mucuna flour blends composite flour

Sample	**Tannin (mg/100 g)**	**Phytate (mg/100 g)**	**Oxalate (mg/100 g)**
Sample 1	0.65^{f}±0.04	2.11^{f}±0.02	0.40^{f}±0.01
Sample 2	0.87^{e}±0.02	2.25^{e}±0.05	5.09^{e}±0.01
Sample 3	0.93^{d}±0.02	2.19^{d}±0.01	8.05^{d}±0.02
Sample 4	1.05^{c}±0.50	2.34^{c}±0.01	9.10^{c}±0.03
Sample 5	1.12^{b}±0.01	2.38^{b}±0.04	9.45^{b}±0.08
Sample 6	1.21^{a}±0.06	2.42^{a}±0.07	9.58^{a}±0.05

Mean value with different superscripts within the same column are significantly different at 5% level. Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

The composition of amino acid of food product gives information about nutritive value of its protein source and it is used in the examination and treatment of a material to detect and remove unwanted fractions of potential protein foods [32]. It was observed that there were significant differences in the amino acid content of the flour samples. Glycine content varied from 4.47 to 4.89 g/100 g, with Sample 1 exhibiting the lowest value while the highest value was found in Sample 6. Alanine value ranged from 3.88 to 4.45 g/100 g, with Sample 6 having the lowest value while Sample 1 had the highest value. Serine, proline, aspartame and glutamate content varied from 5.48 to 5.87 g/100 g, 2.18 to 4.49 g/100 g, 10.91 to 11.97 g/100 g and 14.99 to 15.43 g/100 g respectively with Sample 1 exhibiting the lowest values while Sample 6 had the highest values in all these amino acids. The major abundant amino acids are glutamic acid and aspartate. The results obtained in this study are similar to the research study reported by Adeyeye [33], Aremu et al. (2006) and Olatidoye et al. [32]. According to study of Balogun and Olatidoye [34], amino acid analysis revealed that velvet bean flour contained nutritionally useful essential amino acids which are discovered to increase as the sprouted velvet bean (*Mucuna utilis)* inclusion increased.

In the same vein, the essential amino acids valine, threonine, isoleucine, leucine, lysine, methionine, phenylalanine, histidine, tyrosine and tryptophan content increased as the velvet bean inclusion increased. The values ranged from 4.82 to 6.84 g/100 g, 5.14 to 6.85 g/100 g, 3.65 to 7.81 g/100 g, 5.88 to 8.25 g/100 g, 4.96 to 5.84 g/100 g, 2.29 to 3.05 g/100g, 5.34 to 6.79 g/100 g, 2.24 to 3.13 g/100 g, 3.20 to 4.42 g/100 g and 0.39 to 0.80 g/100 g respectively with Sample 1 exhibiting the least values and Sample 6 having the highest values. One of the main nutritional limitations of maize grain is its deficiency in tryptophan and lysine which are essential amino acid but has a fair amount of methionine [35,36]. Comparatively, the composite flour blends under study has high concentration of amino acid which is higher than 2.68 g/100 g reported by FAO/WHO/UNU [37] for children under two years. This increase implies that composite flour blends under study may be useful in combating protein-energy-malnutrition (PEM) problems which is prevalent among infants in sub-Saharan Africa.

Table 6. Pasting properties of fermented maize-sprouted mucuna flour blends

Sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Pasting time (Min)	Pasting temperature (°C)
Sample 1	$2508.0^{a}\pm1.41$	$1661.5^{a}\pm1.92$	$874.5^{a}\pm1.26$	$2307.0^{a}\pm1.73$	$673.5^{a}\pm2.12$	5.0^{c}	77.85^{a}
Sample 2	$2498.0^{b}\pm2.83$	$1640.5^{b}\pm1.36$	$834.5^{b}\pm3.65$	$2292.5^{b}\pm3.13$	$662.0^{a}\pm2.46$	4.9^{bc}	77.88^{a}
Sample 3	$2456.0^{b}\pm2.43$	$1633.5^{c}\pm1.85$	$815.5^{b}\pm3.06$	$2296.5^{b}\pm1.82$	$656.0^{a}\pm2.46$	5.0^{c}	77.88^{a}
Sample 4	$2344.5^{c}\pm7.48$	$1631.5^{c}\pm3.54$	$683.0^{c}\pm1.56$	$2285.0^{ab}\pm3.36$	$631.0^{a}\pm1.21$	5.0^{c}	77.93^{a}
Sample 5	$2302.4^{d}\pm1.05$	$1615.5^{d}\pm1.15$	$665.6^{d}\pm0.99$	$2275.5^{ab}\pm0.95$	$625.8^{ab}\pm1.05$	5.5^{b}	77.91^{a}
Sample 6	$2120.3^{e}\pm1.22$	$1598.4^{e}\pm1.25$	$650.8^{e}\pm0.55$	$2268.4^{ab}\pm0.05$	$615.5^{ab}\pm0.05$	5.7^{a}	77.95^{a}

Mean values with different superscripts within the same column are significantly different at 5% level.

Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

Table 7. Amino acid profile of fermented maize-sprouted mucuna flour blends mg/100 g

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Adult*	Children*
			Non-Essential Amino Acid (NEAAs)					
Glycine	4.4670	4.7037	4.8332	4.8221	4.8422	4.8994		
Alanine	4.4466	3.6663	3.6085	3.6583	3.7855	3.8775		
Serine	5.4829	6.5440	6.1678	5.1363	5.6678	5.8678		
Proline	2.1827	2.3250	3.0960	4.0868	4.2368	4.4868		
Aspartate	10.9154	11.2191	11.6422	11.7543	11.8813	11.9661		
Glutamate	14.9941	15.0099	14.9522	15.1307	15.2307	15.4307		
Cystine	1.3092	1.4003	1.5020	1.7701	1.8850	1.9784		
Arginine	4.6919	5.0506	5.7643	5.8082	5.9245	6.0884		
Tyrosine	3.2033	3.7219	3.8340	4.0028	4.2028	4.4156		
Valine	4.8280	4.8571	6.1382	6.5362	6.6660	6.8372		
ΣNEAA	53.3178	54.776	57.7044	62.7058	64.3226	65.8479		
			Essential Amino Acid (EAAs)					
Isoleucine	3.6528	5.2711	5.9394	7.1456	7.5455	7.8106	2.0	3.1
Leucine	5.8772	6.3451	7.1528	7.9525	8.1425	8.2520	3.9	7.3
Phenylalanine	5.3403	5.4769	6.2075	6.3773	6.5752	6.7875	2.5	6.9
Methionine	2.2886	2.3736	2.6953	2.7848	2.9245	3.0484	1.5	2.7
Lysine	4.9646	5.5510	5.5924	5.6332	5.7225	5.8402	3.0	6.4
Tryptophan	0.3910	0.4710	0.5900	0.6810	0.7510	0.8010	0.4	1.25
Threonine	5.1395	3.3977	4.4832	5.3622	6.0435	6.8540	1.5	3.7
Histidine	2.2352	2.7834	2.7295	2.7854	2.8891	3.1340	-	1.0
ΣEAAs +Histidine	29.8892	31.6698	35.3901	38.722	40.0938	40.0277		

**RDA of essential amino acids (mg/100g b.w) for Adult and Children (<5 yrs.) (Ragaee and Abdel-Aal , 2006)*

Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

The predicted nutritional qualities of composite flour blends (Table 8) shows that the total sulphur-containing amino acid, total aromatic amino acids, total branch chain amino acid, total essential amino acid and total amino acid is significantly (p>0.05) higher than control (100% maize flour). This implies that the composite flour blends contain more predicted nutritional qualities than control flour samples as this may bring about blood pressure reduction and management of diabetes mellitus as reported by Oluwajuyitan and Ijarotimi [38]. Also, the consumption of this composite flour blends may make less severe amino acid deficiency through the use complementary foods from legumes and nuts. Essential and non-essential amino acid compositions increased with increased concentration of sprouted velvet bean flour. Among non-essential amino acids (glutamic acid and arginine) accounted for almost 45% of the total concentration of amino acids present in the flour. Aromatic amino acid (ArAA) determined in this study, (8.5–11.2 g/100 g), is however less than the protein value recommended for infants (6.8–11.8 g/100 g) suggested by FAO/WHO/UNU, (1985). The changes in the amino acids may be attributed to hydrolysis of polypeptides, resulting in an increase and subsequently undergoing a serve of chemical reaction that results in a decrease of the total amino acids.

3.7 Sensory Evaluation of Porridge from Maize Flour Supplemented with Sprouted Velvet Bean Flour

Table 9 indicates the sensory values of porridges produced from the blends of maize and velvet bean flour. The results showed that significant differences exist between the control and the

Table 8. Predicted nutritional qualities of maize flour supplemented with sprouted velvet bean flour

Amino acid	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
ARG/LYS	0.945	0.910	1.031	1.031	1.035	1.043
TSAAs	3.5978	3.7739	4.1973	4.5549	4.8095	5.0268
TArAAs	8.5436	9.1988	10.0415	10.3801	10.9780	11.2031
TBCAAs	14.358	16.4733	19.2304	21.6343	22.354	22.8998
TEAAs	29.8892	31.6698	35.3901	38.722	40.0938	40.0277
TNEAAs	53.3178	54.776	57.7044	62.7058	64.3226	65.8479
EAA/NEAA	0.56	0.58	0.61	0.62	0.62	0.61
Leu/Ile ratio	1.62	1.20	1.1	1.1	1.1	1.1
TAAs	83.207	86.4458	93.10	101.4278	104.4164	105.8756

ARG /LYS: Arginine/ Lysine; TSAAs: Total Sulphur Containing Amino Acids (Methionine + Cysteine); TArAAs: Total Aromatic Amino Acids (Phenylalanine + Tyrosine); TBCAAs: Total branch chain amino acids (Valine + Leucine + Isoleucine); TEAAs: Total essential amino acid; TNEAAs: Total non-essential amino acid; TAAs: Total amino acids

Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

Table 9. Sensory evaluation of porridge produced from fermented maize-velvet bean flour blends

Samples	Colour	Taste	consistency	mouth feel	Appearance	Overall acceptability
Sample 1	6.25^{a}±0.06	6.85^{a}±0.88	5.75^{a}±1.05	6.05^{a}±0.02	6.05^{a}±0.02	5.88^{a}±0.05
Sample 2	6.05^{b}±1.31	6.55^{a}±1.67	5.10^{b}±1.07	5.85^{b}±1.23	5.90^{a}±1.39	5.65^{b}±1.27
Sample 3	5.85^{c}±1.39	5.30^{b}±1.38	4.40^{c}±1.27	4.85^{c}±1.31	5.85^{b}±1.36	4.05^{c}±1.00
Sample 4	5.28^{d}±1.33	4.00^{c}±1.45	3.90^{d}±1.02	4.35^{d}±1.35	4.45^{c}±1.10	3.10^{d}±0.85
Sample 5	4.85^{e}±0.02	3.55^{d}±0.05	3.05^{e}± 0.05	3.25^{e}±0.05	3.15^{d}±0.99	$2..80^{e}$±0.25
Sample 6	3.35^{f}±0.01	3.02^{e}±0.02	2.85^{f}±0.04	3.05^{f}±0.15	3.05^{e}±0.08	2.25^{f}±0.15

Mean values with different superscripts within the same column are significantly different at 5% level.

Sample 1- 100% locally fermented maize flour, Sample 2- 90% sprouted mucuna flour and 10% maize flour, Sample 3-80% sprouted mucuna flour and 20% maize flour, Sample 4- 70% sprouted mucuna flour and 30% maize flour, Sample 5- 60% sprouted mucuna flour and 40% maize flour, Sample 6- 50% sprouted mucuna flour and 50% maize flour

composite blends for all parameters examined except colour, taste and appearance. The mean sensory scores of the control and the composite samples differed significantly in colour, consistency and overall acceptance. The appearances of all flour blends were moderately liked by the panelists. Colour is an important sensory evaluation because it influences the acceptability of any food product. This also gives important information on suitability of food product and formation of quality product. The appearance and overall acceptability were slightly and dislike moderately respectively. Sample 2 was most acceptable among the experimental samples with Sample 1 having more acceptability in all the sensory parameters evaluated. It was observed that the addition above 10% velvet bean flour affected the palatability which may have induced effect on the quality of the product. Also, other sensory attributes were reduced as the inclusion of the velvet bean flour increased which is similar to the trend reported by Aminigo and Akingbala [39].

4. CONCLUSION

The inclusion of sprouted velvet bean flour improved the protein, calorie and amino acid content but lower in antinutritional factors. It can be concluded from the results of this study that sprouted velvet beans flour supplementation with maize flour enhanced the nutritional composition of the steamed stiff paste. Velvet bean is also readily available and very cheap and it will have little or no effect on the price of the product. Therefore, a mixture of this composite flour will provide enough protein for maintenance of the body cells, good health and prevention of nutritional deficiency diseases. Meanwhile to further reduce the antinutrients in the samples to safe level, combine methods of sprouting and roasting could be employed.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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