



Physicochemical Composition of Processed Velvet bean *Mucuna pruriens* Var Utilis Seed Flour and Consumer Acceptability of Bitter Leaf Soup Thickened using these Flours

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Authors' contributions

This work was carried out in collaboration among all authors. Author RNA who is the lead author designed and supervised the work. Author CRO performed the research including the literature search, laboratory and wrote the first draft. Author JIA performed the statistical analysis, co-supervised the work. Both authors JIA and RNA read through the paper and made inputs. All authors read and approved the final manuscript.

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ABSTRACT

The study investigated the effect various processing treatments on the physicochemical composition of mucuna seed flour and consumer acceptability of bitter leaf soups thickened using these flours. *Mucuna pruriens* var utilis seeds were processed by roasting, microwave toasting, steeping and boiling and/or a combination of these treatments followed by drying for 48 hours and milling into flour. The processed flours were used to thicken bitter leaf soup and consumer acceptability of the soups were evaluated by sensory evaluation and data generated were statistically analyzed. The results showed that the proximate composition of samples ranged from 10.71- 22.94 %; 14.25 to 17.95 %; 2.43 - 9 4.93%. 0.59-3.27%, 2.62-5.68%, 48.43% - 57.40% of crude protein, moisture; ash, fiber, fat and carbohydrate respectively, with the sample MB (boiled mucuna seed) having the highest protein content. The Overall acceptability score ranged from 6.00 to 8.06 with the sample MSB (steeped and boiled mucuna seed flours) having the highest score while the mean scores for taste, aroma and mouth feel ranges from 7.67– 8.00; 6.53 – 7.67; 6.13 –

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7.93 respectively. Therefore, with an overall acceptability rating of 6-8 for all the soups, processed *Mucuna* seed could favorably compare with other soup thickeners especially the soaked and boiled *Mucuna* seed flour.

Keywords: Velvet bean; flours; *Mucuna* seed.

1. INTRODUCTION

Soups are one of the most important dishes on the everyday menu of an average Nigerian. They are a major part of the diet of many low-income people and large families. Hence, the many varieties of soups consumed in the southern part of Nigeria such as "egusi" (*Colocynthis citrullus* L.), "oha", (*Pterocarpus mildraedii*) "onugbu" (*Vernonia amygdalina*), "okazi" Gnetum Africanum), "uziza" (*Piper guineense*), etc. However, a common ingredient used in their preparation to increase their desirability for use in eating gari, 'fufu', pounded yam etc is starchy thickeners. Bitter leaf (*Vernonia amygdalina*) soup is usually a semi liquid tasty, nutritious and wholesome foods used in eating gari, fufu, pounded yam etc.

The soup is normally prepared by stewing of ingredients such as meat, dry fish, washed bitter leaf (de-bittered), garnished with seasonings and thickened using cocoyam paste. Bitter leaf soup has remained for a long time the dish of the low-income earners in the Southwest and south east region of Nigeria. However it is gradually becoming very popular as the soup used in many marriage and burial occasions for the entertainment of guests. In Nigeria and some West African Sub region, the conventional sources of thickening agents are mainly starchy plants such as cocoyam, yam; oil seeds such as egusi (*Colocynthis citrullus* L.), ogbono (*Irvingia gabonensis*) and legumes like Ukpo (*Mucuna solanifera*), Achi (*Brachystegia eurycoma*), ofo (*Detarium microcarpum*) [1]. The seed flour from these thickening agents have gelation properties and imparts a gummy texture when used in soups, which is a desirable attribute necessary for the eating of garri, pounded yam, etc [1].

The high demand for flours from these conventional soup thickening agents such as egusi, ogbono (*Irvingia gabonensis*), achi (*Brachystegia eurycoma*), ofo (*Detarium microcarpum*), *Mucuna sloanei*, peanut etc, had thus resulted in escalating cost of these conventional thickeners. Hence, there is need for the replacement of these expensive conventional

protein rich or starchy (coco yam) thickeners with cheap locally available, lesser known and lesser utilized substitutes in soup formulation as this will offer a veritable means of reducing the total cost of soup production. Nutritionists are thus exploring various alternative sources of protein rich seeds with a view to reducing the high cost of providing adequate diet for the ever teeming population, increase utilization of such lesser known seeds, encourage their cultivation and increase income generation.

Mucuna pruriens var *utilis* commonly known as velvet bean is one of the indigenous edible plants which could be used as food thickener and gums in Nigeria and other West African countries. Some recently conducted researches showed that *Mucuna pruriens* var *utilis* seed and a host of others have been successfully used as protein source in livestock nutrition particularly monogastric animals [2,3]. Roasted and coarsely ground *Mucuna* seed flours are at present used traditionally in Nsukka eastern Nigeria as a soup thickener for eating three leaf yam (una). They are used as thickening agents in the preparation of several food recipes [4]. Tribes in Africa use roasted and finely powdered dry *Mucuna* seeds as a supplement for coffee. Studies in the past showed that *Mucuna* beans are processed into flour or eaten as a vegetable by a large population of tropical nations owing to their high starch content, protein, and fiber [5], which significantly enhances its functional applications for the formulation of different food products. However, its use as food for human is limited, perhaps, due to the various processing treatment it is subjected to before it is safe for consumption. As a source of protein, the *Mucuna pruriens* var *utilis* bean has been investigated extensively, as having a variety of treatment procedures for detoxification of the seeds and their culinary preparations [6,7]. Such processing treatments include toasting, prolonged soaking, boiling and cracking open of the seeds before they are eaten [8]. However, not much has been done on the effect of these processing variables on the proximate composition of the flour and its use as a soup thickener. It is in view of this, that this work was designed to investigate the effect of roasting, boiling and microwaving and/ or a

combination of these treatments on the proximate composition and its potential application as a soup thickener. The replacement of expensive conventional protein rich thickeners with cheap locally available, lesser known and lesser utilized substitutes in soup formulation offer a veritable means of reducing the total cost of soup production. This work is justified from the standpoint of value addition to mucuna as this will enhance the broader utilization, increase possibility of its application as soup thickener, encourage farmers mass production and reduce problem of malnutrition in the developing nations especially West African sub region. Therefore, the main objective of this study was to determine the effect of some processing variables on the physicochemical properties and consumer acceptability of the soups thickened with the processed seed flour by sensory evaluation.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

The freshly harvested and dried *Mucuna* seeds, the ingredients for soup preparation (dry fish, meat, stock fish, seasoning, pepper, bitter leave, 100 % red oil, Salt.) were procured from Ogige Market Nsukka, Enugu State, Nigeria.

2.2 Sample Preparation

The seeds were cleaned by sorting out stones and extraneous material. Two thousand five hundred grams (2500 g) of the cleaned seeds were weighed out. The seeds were divided into five batches consisting of 500 g each, one batch was roasted in a fire for 25 minutes and dehulled, the second batch was toasted in a microwave oven for 5 minutes and dehulled, the third batch was steeped in tap water (1:2 w/v) for 2 hours at room temperature (28 - 90 °C) and microwaved for 5 minutes followed by dehulling and oven drying at 50 °C for 48 hours. The fourth batch was boiled for 20 minutes, dehulled and dried in the oven at 50 °C for 48 hours while the fifth batch was steeped for 2 hours, boiled for 20 minutes and dehulled followed by oven drying at 50 °C for 48 hours. The processed seeds were ground in a hammer mill and stored in a screw-cap container until testing was needed.

2.3 Soup Preparation

One hundred and twenty grams (120 g) of the various processed *mucuna pruriens var utilis*

flour were mixed with thirty milliliters (120 ml) of palm oil respectively at ratio of 1:1 (W/V) to form a stable emulsion and used to emulsify 1200 ml of meat stock water used in preparing the soup. The ratio of the processed *Mucuna pruriens var utilis* flour and palm oil mixture to the meat stock was 1: 5 (w/v). The mixture was heated up for five minutes followed by the addition of 60 g of ground crayfish, six hundred grams (600 g) of washed bitter leaf, two cubes of seasoning (monosodium glutamate), salt and pepper were added to taste. The soup was further stewed for another 5 minutes.

2.4 Analyses

2.4.1 Physicochemical Analysis

The processed seed flours were analyzed for the following chemical properties. Proximate composition by the methods described in Association of Official Analytical Chemist [9]; oxalate, phytate and tannin contents were determined by the method of Baker [10], Wheeler and Ferrel [11] and Harborne [12] respectively.

2.5 Determination of Functional Properties

2.5.1 Water absorption capacity

The method of Beuchat [13] was used to determine the water absorption capacity of the flour sample. One gram of each flour sample was weighed into a graduated centrifuge tube and 10 ml of distilled water added. The mixture were stirred for a minute and allowed to stand at room temperature for 30 minutes. After that, the mixture was centrifuged at 5000 rpm for 30 minutes and the volume of the free water will read and recorded immediately after centrifugation.

$$\% \text{ Water absorption} = \frac{\text{Volume of water absorbed}}{\text{weight of sample}} \times \frac{100}{1} \dots \dots \dots \text{Equation (1)}$$

2.5.2 Determination of oil absorption capacity

The method of Onwuka [14] was used for this determination of each flour Sample. Two grams of the flour was weighed in each case into a conical graduated centrifuge tube. Ten millimeter of oil was added and the mixture stirred for 10 minutes at room temperature. The mixture was centrifuged at 5000 rpm for 30 minutes. After centrifugation, the volume of oil (supernatant) was read directly from the centrifuge tube. The

oil absorption capacity of the sample was calculated using the expression below:

$$\% \text{ oil absorption capacity} = \frac{\text{volume retained}}{\text{weight of sample}} \times \frac{100}{1}$$

Equation (2)

2.5.3 Determination of gelation properties

The method of Coffman and Garcia [15] method modified by Okaka *et al.*, [16] method was adopted for the determination of gelation property. The gel characteristic and least gelation concentration of flour samples were determined by modifying the method of Coffman and Garcia [15]. Different weights of flour samples were dispersed in 10cm³ of distilled water in duplicate test tubes to give flour dispersions of different concentrations (4-35 % w/w). The tubes will be heated in a boiling water bath for 15 minutes and then cooled to room temperature by dipping the test tube in water. The tubes were inverted and the least flour concentration to form a well developed gel which did not flow out of the inverted tube noted. The amount of liquid which flowed out of the tubes of improperly formed gels was also noted. The relative gel strength of samples was subjectively determined by pressing gels between fingers.

2.5.4 Determination of foaming capacity

The foaming capacity of the flours and blends were determined using Coffman and Garcia [15] method, modified by Okaka *et al.* [16]. One gram of sample (in duplicate) was dispersed in 100cm³ distilled water (pH 6.8) and whipped for 5 minutes in a Kenwood blender (Model, 707) set at No. 5 speed. The volume of sample before and after whipping was determined by pouring into a 250 cm measuring cylinder. The percent increase in volume due to whipping will recorded as the foaming capacity. For measurement of specific absorption (water and oil), one gram of each sample (in duplicate) was mixed with 10 cm³ distilled water or oil in a calibrated test tube. The samples with water or oil after shaking for 4 minutes (water) and 6 minutes (oil) were allowed to stand at room temperature (25°C) followed by centrifugation at 4,500 x g for 20 minutes. The volume (cm³) of free water or oil in the tube after standing was noted and the water or oil absorption was expressed as the volume of water/oil absorbed by 1 g sample (specific absorption).

2.5.5 Determination of emulsifying capacity

Beuchat (13) method was adopted. The flour sample (16 g) was suspended in 100 ml of water

in a jar. The suspension was blended for 30 seconds (using a suitable blender). From a burette, Peanut oil was added (at the rate of 0.5 ml per second), to the blending sample till the breakpoint of the mixture will be reached. Then there was a brisk stirring for 30 seconds before heating at 30°C, 50°C, 70°C and 80°C while agitated with a magnetic stirred at the selected temperature which was maintained over a stirrer hot plate. The viscosity of the cold gelatinized paste will be measured using the Brookfield viscometer.

2.6 Sensory Evaluation

A 20 man semi-trained panelists recruited from Staff and students of Madonna University, Akpugo Campus were used for the sensory evaluation of the various *Mucuna pruriens* var utilis soup prepared using the processed seeds. The panelists included both males and females. A 9-point hedonic scale as described by Iwe [17], with a scaling range of 1-9 [with 1= dislike extremely; 2= dislike very much, 3= dislike moderately, 4 = dislike slightly, 5= neither dislike or like, 6= like slightly, 7= moderately, 8= like very much and 9= like extremely] was used for the evaluation of the prepared soups for Appearance, taste, aroma, mouth feel and consistency attributes in one session. The soups were served to the panelists in the Food science Laboratory at room temperature (28 ± 2 °C - 122 °C). The panelists were instructed to rinse their mouths with potable water after evaluating each sample. Data from the hedonic test were subjected to statistical analyses using the statistical package for social sciences (SPSS) version 11 for windows.

2.7 Data Analyses

Determinations were carried out in triplicate and the error reported as standard deviations from the mean. Data were subjected to one way ANOVA; Duncan's New Multiple Range Test [17] was used to separate the means for each treatment. Significance was accepted at p<0.05 level.

3. RESULTS AND DISCUSSION

3.1 Proximate Compositions of the Processed *Mucuna pruriens* var utilis Seed Flours

The proximate compositions of the processed *Mucuna utilis* seed flour (Velvet bean) are shown in Table 1. The protein content of the processed

Mucuna utilis flour ranged from 10.71-22.94 %. Sample M_B (boiled mucuna seed flour) had the highest crude protein content (22.94 %) while M_R (Roasted mucuna seed flour) had the least protein content of 10.71 %. The lower protein content of sample M_R could be attributed to denaturation of the protein in the roasted sample. There was significant difference ($P < 0.05$) among the five samples. It was also observed that soaking of the bean before toasting increased the protein content by 3.05 % while it resulted in a decrease of the protein content in the case of boiled sample M_{SB} (18.89 %) while M_B (22.94 %). The result of this work is similar to the 25.65 % crude protein reported for raw velvet bean seed [18].

The ash content of the flours ranged from 2.43 - 4.93%. Sample M_T (Toasted mucuna seed flour) had the highest value (4.93 %) while sample M_{ST} (steeped and toasted) sample had the least value (2.43 %). The lower ash content of sample M_{ST} could be attributed to leaching out of mineral elements during steeping. A similar trend was observed between M_B (4.62 %) and M_{SB} (2.79 %). There was significant difference ($P < 0.05$) among the samples. Ash content is an indication of the mineral content of food. This result suggests that the toasted sample will be best suitable in applications where mineral elements are desired.

The crude fiber content of the samples ranged from 0.59-3.27 %, with sample M_B having the highest value (3.27 %) and M_{ST} sample having the least value of 0.59 %. This low value for the M_{ST} could be due to the partial break down of carbohydrate materials of *Mucuna utilis* seed

during steeping and subsequent toasting and dehulling; since carbohydrate materials for example cellulose, hemi-cellulose and gums form the principal source of crude fiber in food materials [19].

Moisture content of the samples ranged from 14.25 to 17.95 % with M_R having the least value while M_B had the highest value. There was significant difference ($p < 0.05$) among the samples. The lower moisture content of the M_R compared to the boiled sample M_R could be attributed to the effect of dry heat of roasting while the boiled samples must have imbibed more moisture during boiling with the resultant effect. This implies that samples processed using dry heat would have a longer shelf life than the wet heat processed samples hence, reduced proliferation of spoilage organisms especially molds, improving the shelf stability of the product.

The fat content ranged from 2.62-5.68 %. M_B had the lowest value while M_{SB} had the highest. This implies that foods prepared using this flour would be energy dense foods suitable for people such as sportsmen that require lot of energy to work.

The carbohydrate content of the flour samples varied from 48.43% - 57.40 % with M_B having the lowest and M_{ST} had the highest. There was significant difference ($P < 0.05$) in carbohydrate content among the samples. This trend in increase in protein content and decrease in carbohydrate content of boiled bean flour is expected since *Mucuna utilis* bean flour is rich in proteins [18].

Table 1. Effect of Processing on the Proximate Composition of *Mucuna pruriens var utilis* seed flour

Sample	Crude Protein %	Ash %	Crude Fibre %	Moisture %	Fats %	Carbohydrates %
MB	22.94e±0.02	4.62c±0.02	3.27e±0.02	17.95e±0.02	2.62a±0.28	48.43a±0.02
MR	10.71a±0.02	4.59c±0.02	1.19b±0.02	14.25a±0.02	4.99c±0.02	64.27e±0.02
MT	17.58b±0.02	4.93d±0.02	1.35c±0.02	15.30c±0.02	3.83b±0.02	57.01c±0.01
MSB	20.63d±0.02	2.79b±0.02	1.39d±0.02	16.71d±0.02	3.74b±0.02	54.74b±0.02
MST	18.89c±0.06	2.43a±0.02	0.59a±0.02	15.03b±0.02	5.68d±0.02	57.40d±0.02

Results are the means of three replications. Means within a column with the same superscripts are not significantly different. Key. MB=Mucunautilisseed boiled, MR =Mucunautilis seed roasted, MT=Mucunautilis toasted, MSB = Mucunautilisseed steeped and boiled MST =Mucunautilis seed steeped and toasted;

3.2 Functional Properties

The functional properties of the processed *Mucuna utilis* bean flour are shown in Table 2. The water absorption capacities (WAC) of the flours ranged from 100.24-102.26 ml/ g with sample M_{SB} having the highest value of 102.26ml/g. There was significant difference (P< 0.05) difference in the WAC of the flours. The observed variation in water absorption capacities between flour maybe attributed to different protein concentrations, their degree of interaction with water and their conformational characteristics [20] affected by the method of processing. Water absorption capacity is an important functional property required in food formulations such as soups, gravies, doughs and baked products [21]. Water absorption capacity is important in bulking and consistency of products [22]. *Mucuna* bean could be useful in these formulations. Liquid retention is an index of the ability of proteins to absorb and retain water which in turn influences the texture and mouth feel characteristics of foods and food products like comminuted meats, extenders or analogues and baked dough [23,24]. Hence, in terms of WAC sample M_{SB} is the best sample.

Oil absorption capacity of the flour samples ranged from 0.78-0.93 with M_{ST} (0.775) having the lowest and M_T (0.93) having the highest value. There was significant (p < 0.05) difference in the oil absorption capacity of the flour samples. The lower oil absorption capacity of sample M_{ST} could be as a result of steeping of the seeds before toasting. Oil absorption capacity is an important functional property that enhances the mouth feel while retaining the flavor of food products. High oil absorption capacity is desirable for flours used as

thickeners, based on this sample M_T is the best sample.

The emulsion capacity (EC) of the flours ranged from 0.53-0.69with sample M_B having the highest and sample M_{ST} having the lowest value. The emulsion capacity of the flour samples differed significantly (p < 0.05).

The higher emulsion capacity of M_B could be attributed to the higher protein content of M_B compared to the other samples. The EC of proteins is related to their ability to reduce the interfacial tension between oil and water in the emulsion. Surface activity is a function of the protein ability to migrate, absorb, deploy, and rearrange at an interface [25].

The foaming capacity of the samples ranged from 2.98- 3.56 % with sample M_{SB} having the highest value and M_T having the least value. The analysis of variance showed significant differences between the flours. The lower foaming capacity of M_T could be attributed to denaturation of the proteins due to dry heat of toasting. High foaming capacity is not a desirable property for flours for use as soup thickeners. Hence in term of foaming capacity, sample M_T is the best sample.

The least gelation capacity of mucuna flours was 6.00 % for all the samples this implies that irrespective of the processing treatment given the flours will form gel at the same flour concentration. There was no significant difference between the samples (p > 0.05). Gelation takes place more readily at higher protein concentration because of greater intermolecular contact during heating. High protein solubility is always necessary for gelation as observed by Wilton et al. [26].

Table 2. Functional properties of *Mucuna utilis* seed flour

Sample	% WAC	OAC (g/g)	% Emulsion	% Foam	% Gela
M _B	100.24 ^a ±0.01	0.86 ^c ±0.00	0.69 ^d ±0.00	3.36 ^c ±0.00	6 ^a ±0.00
M _T	101.25 ^c ±0.00	0.93 ^e ±0.00	0.58 ^b ±0.00	2.98 ^a ±0.00	6 ^a ±0.00
M _R	100.35 ^b ±0.00	0.88 ^d ±0.00	0.66 ^c ±0.00	3.18 ^b ±0.00	6 ^a ±0.00
M _{SB}	102.26 ^d ±0.00	0.84 ^b ±0.00	0.58 ^b ±0.00	3.56 ^d ±0.00	6 ^a ±0.00
M _{ST}	101.45 ^c ±0.01	0.78 ^a ±0.00	0.53 ^a ±0.00	3.29 ^b ±0.00	6 ^a ±0.00

Key: Results are the means of three replications. Means within a column with the same superscripts are not significantly different. MB= *Mucuna utilis* seed boiled, MR =*Mucuna utilis* seed roasted, MT=*Mucuna utilis* toasted, MST =*Mucuna utilis* seed steeped and toasted; MSB = *Mucuna utilis* seed steeped and boiled. WAC=water absorption capacity, OAC=oil absorption capacity, EMULCI=emulcification capacity, FOAM=foaming capacity, GELA= Least gelation capacity

3.3 Pasting Properties

The pasting properties of the processed *Mucuna pruriens* seed flours are presented in Table 3. The Peak viscosity (PV) of the processed *Mucuna pruriens* seed flours ranged from 165.3RVU to 268.1RVU. Sample M_{SB} had the highest value while M_R had the lowest value. The higher PV of M_{SB} could be attributed to its higher WAC compared to the other samples. This implies that sample M_{SB} will swell more than the other samples and have a more thickening effect. There were significant differences among the five flour samples at ($p < 0.05$). These values were similar to the peak viscosity (119.67-278.17) reported for maize cowpea and maize bambara ground nut complementary foods [27]. The peak viscosity is indicative of the strength of pastes, which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling.

The trough value ranged from 100.33RVU to 205.83RVU. M_T had the highest TV value while M_R had the lowest. There were significant differences among the five flour samples at ($p < 0.05$). TV measures the ability of the paste to withstand breakdown during cooling.

3.4 Breakdown Viscosity (BV)

The (BV) value ranged from 57.22RVU to 64.59RVU. M_R had the highest value while M_B had the lowest value. There were significant differences among the five flour samples at ($p < 0.05$). Breakdown viscosity reflects the stability of the paste during processing. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress during processing. High breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the

starch in question possesses cross-linking properties. This implies that sample M_B possesses cross-linking properties and will withstand heating and shear stress.

The Final viscosity (FV) value ranged from 198.62RVU to 339.58RVU. The highest value of the final viscosity was recorded for M_{ST} while the lowest was recorded for M_T. There were significant differences among the five flour samples ($p < 0.05$) for final viscosity. Final viscosities are important in determining the ability of the flour sample to form a gel during processing.

Set back viscosity value ranged from 61.15RVU to 133.08RVU. The highest value of setback viscosity was recorded for M_{ST} while the lowest value for setback was recorded in M_{SB}. There were significant differences among the flour samples for setback. Set back viscosity indicates gel stability and potential for retro-gradation. High setback value is an indication of the propensity of the starch molecules to disperse in hot paste and re-associate readily during cooling.

Peak time value ranged from 5.55 min to 6.72 min. There were significant differences among the five flour samples ($p < 0.05$). Peak time values reported in this work are similar to the peak time values of 5.13–5.80 min and 5.01–6.30 min reported for instant yam–breadfruit composite flour [28].

Pasting temperature value ranged from 91.48°C to 93.85°C. There were no significant differences among the five flour samples at ($p > 0.05$). The attainment of the pasting temperature is essential in ensuring swelling, gelatinization and subsequent gel formation during processing. The pasting temperature (PT) is the temperature at which the viscosity starts to rise.

Table 3. Pasting properties of *Mucuna utilis* seed flour

Sample	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Visc (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp(°C)
M _B	165.3 ^a ±0.05	108.0 ^b ±3.05	57.22 ^a ±1.99	236.4 ^c ±5.03	71.12 ^b ±2.00	5.56 ^a ±0.01	93.65 ^a ±0.02
M _T	190.0 ^b ±0.04	131.3 ^c ±2.00	58.75 ^a ±0.02	198.6 ^a ±2.00	67.35 ^b ±2.00	6.35 ^c ±0.00	92.44 ^a ±1.80
M _R	162.9 ^a ±0.05	100.3 ^a ±1.98	64.59 ^b ±4.00	227.3 ^b ±0.00	62.41 ^a ±3.05	6.48 ^d ±0.02	91.48 ^a ±0.02
M _{SB}	268.1 ^c ±0.02	109.0 ^b ±2.00	60.38 ^b ±2.00	230.5 ^b ±2.30	61.15 ^a ±0.50	6.28 ^b ±0.00	93.85 ^a ±2.00
M _{ST}	169.4 ^a ±0.01	205.8 ^d ±2.51	62.33 ^b ±2.00	338.9 ^d ±5.03	133.0 ^c ±3.00	6.72 ^e ±0.46	93.73 ^a ±2.00

KEY: Results are the means of three replications. Means within a column with the same superscripts are not significantly different. MB= *Mucuna utilis* seed boiled, MR =*Mucuna utilis* seed roasted, MT=*Mucuna utilis* toasted, MST =*Mucuna utilis* seed steeped and toasted; MSB = *Mucuna utilis* seed steeped and boiled

Table 4. Anti-Nutrient Composition of Processed *MucunaUtilis* Seed Flour

Samples	Oxalates	Phytates	Tannins
M _B	0.0602 ^e ±0.00	0.0970 ^a ±0.00	0.2353 ^b ±0.00
M _T	0.0213 ^c ±0.00	0.0357 ^a ±0.00	0.2850 ^c ±0.00
M _R	0.0070 ^a ±0.00	0.0103 ^a ±0.00	0.2160 ^a ±0.00
M _{SB}	0.0293 ^d ±0.00	0.0407 ^a ±0.00	0.3740 ^d ±0.00
M _{ST}	0.0100 ^b ±0.00	0.0196 ^a ±0.10	0.3820 ^e ±0.00

Results are the means of three replications. Means within a column with the same superscripts are not significantly ($p < 0.5$) different.

Key: MB= *Mucunautilis* seed boiled, MR =*Mucunautilis* seed roasted, MT=*Mucunautilis* toasted, MST =*Mucunautilis* seed steeped and toasted; MSB = *Mucunautilis*seed steeped and boiled

3.5 Anti Nutritional Content of *mucuna utilis* Seed Flours

The anti nutritional content of *mucuna pruriens* flours is presented in table 4. The oxalate content of the flours ranged from 0.0070 – 0.0602 mg/g with sample m_r (0.0070 mg/g) having the lowest. the lower oxalate content of sample

M_R could be attributed to effect of dry heat on the oxalate content of the seeds. However, the oxalate content of the samples were within safe level

The tannin content of the samples ranged from 0.021-0.382 mg/g with sample M_R (0.021 mg) having the least value and there was significant difference ($P < 0.05$) between them. Roasting was more effective in reducing the tannin content that the other treatments. Tannins are capable of forming insoluble complexes with proteins which in turn reduce protein digestibility as a result of inactivation of digestive enzymes and interaction of protein substrate with ionisable iron.

The phytate content of the flours ranged from 0.0103 – 0.097 mg/g, with sample MR (0.0103 mg/g) having the lowest value and sample M_B (0.097 mg) having the highest value this implies that roasting was more effective in reducing the phytate content of *Mucuna* flour than the other treatments. Phytic acid binds trace elements and macro-elements such as zinc, calcium, magnesium and iron making dietary minerals unavailable for absorption and utilization by the body. However, phytate, tannin and oxalate contents were within the acceptable limit that is not detrimental to health. Hence all the processed flours are safe for consumption.

3.6 Sensory Evaluation of the *Mucuna* Seed Flour Bitter Leaf Soup

The result of the sensory evaluation for *mucuna* utilis soup rating is shown in Table 5. For all the sensory parameters tested, there were significant differences ($p < 0.05$) among the 5 samples of soup. The rating for appearance by physical examinations ranged from 6.60 – 7.87 sample M_{ST} scoring the lowest and sample MST scoring the highest. This result is in agreement with that obtained by Babayeju et al [30] that food appearance evokes an initial response, flavor and also determines the final acceptance of the food. The score for taste ranged from 7.67– 8.00; sample M_{SB} had the highest taste score while M_{ST} had the lowest score. The lower score on taste for sample M_{ST} could be as a result of effect of toasting of the seed which brings out the beany flavor of the seeds since taste is the sensation of flavor perceived in the mouth and the throat on contact with substrate and it is one of the most important attribute watched out for in a product. The taste of the product could be affected by the type and quantity of ingredients added such as spices and seasoning. Therefore variation in taste depends on the composition of the raw material (*Mucuna* seed flour) used in the preparation of the samples [31].

The mean scores for aroma ranged from 6.53 – 7.67 for all the samples, sample MSB had the highest and M_{ST} the lowest. There was no significant difference ($p < 0.05$) between samples M_{SB}, M_B, M_T and M_R which indicates that the four samples were perceived as the same by the panelist. M_T and M_R had the best aroma and M_{ST} had the least.

Table 5. Effect of processed Mucuna seed Flour on the Sensory Properties of bitter leaf Soup

Samples	Attributes					
	Appearance	Taste	Aroma	Mouthfeel	Consistency	Overall quality
MB	6.87 ^{ab} ±1.72	7.87 ^b ±0.74	7.60 ^b ±0.98	7.67 ^{bc} ±0.97	6.60 ^b ±1.24	7.46 ^b ±0.74
MSB	7.67 ^b ±0.90	8.00 ^b ±1.06	7.13 ^{ab} ±1.18	7.93 ^c ±0.88	7.93 ^c ±0.96	8.06 ^c ±0.59
MST	6.33 ^a ±1.34	6.20 ^a ±1.52	6.53 ^a ±0.91	6.13 ^a ±1.35	5.13 ^a ±1.59	6.00 ^a ±0.75
MT	7.40 ^b ±1.18	7.67 ^b ±0.81	7.67 ^b ±1.04	6.87 ^{ab} ±0.83	6.00 ^{ab} ±1.25	7.26 ^b ±0.79
MR	7.47 ^b ±0.83	7.93 ^b ±1.10	7.67 ^b ±1.04	7.00 ^b ±1.41	5.93 ^{ab} ±1.38	7.24 ^b ±0.50

Results are the means of three replications. Means within a column with the same superscripts are not significantly ($p < 0.5$) different.

Key: MB= *Mucuna utilis* seed boiled, MR =*Mucuna utilis* seed roasted, MT=*Mucuna utilis* toasted, MST =*Mucuna utilis* seed steeped and toasted; MSB = *Mucuna utilis* seed steeped and boiled

This result is similar to the result obtained by Babayeju et al [28] that the odor of Soybeans drives some homemakers away from utilizing it.

The mean scores for mouth feel ranged from 6.13 – 7.93 for all the samples. Sample M_{SB} had the highest and M_{ST} the lowest. There was significant difference ($p > 0.05$) between the samples. Although it may be of the most important organoleptic properties, food mouth feel is probably the least understood and most neglected by food developers. When creating a new food producer or redesigning an existing one, food developers must worry about rheological properties [31].

Consistency scores ranged from 5.13 to 7.93 with M_{ST} as the lowest and M_{SB} as the highest. There was no significant difference ($p < 0.05$) among samples M_B, M_T, and M_R in the consistency of the soup samples.

Overall Quality score ranges from 6.00 to 8.06. Sample M_{SB} (8.06) had the highest score, while sample M_{ST} had the least score (6.00). There was no significant difference ($P > 0.05$) between sample M_B, M_T and M_R which means the three samples were perceived as similar to each other by the panelist. Sample MSB having the highest score of 8.06 indicates that it was generally well accepted. Overall Quality refers to the general acceptance of the product with reference to all the discriminating sensory attributes of the samples. Therefore with overall acceptability rating of 6-8 for all the soups, it follows that processed mucuna seed could favorably compare with other soup thickeners especially the soaked and boiled mucuna seed.

4. CONCLUSION

Processing treatment significantly affected the proximate composition, anti-nutrient composition and functional properties of the mucuna seed

flours especially dry heat treatments. A combination of steeping and boiling of the seeds improved the proximate composition, reduced the anti-nutrients and the soup prepared with this flour was rated the highest in term of overall acceptability by the panelist. Hence it is recommended that the seeds be steeped in water followed by boiling. The results of sensory study showed that the processed seeds can be used for thickening of soups and that it can compare with the conventional thickeners since the overall acceptability score was high.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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