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EFFECT OF DIFFERENT PROCESSING METHODS ON THE CHEMICAL, FUNCTIONAL AND PHYTOCHEMICAL CHARACTERISTICS OF VELVET BEANS (*Mucuna pruriens*)

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ABSTRACT: This study investigated the chemical, functional and phytochemical characteristics of velvet beans. The seeds were procured, sorted, cleaned and equal portions subjected to different treatments viz; Soaking, fermentation and boiling – all prior to dehulling, drying and milling. The raw seed served as the control. The flour samples were subjected to chemical, functional and phytochemical analyses. The results of the chemical analysis revealed a moisture content range of 9.53 – 11.58%, ash (3.18 – 3.44%), crude protein (23.19 – 25.26%), crude fat (6.63 – 6.84%), crude fibre (5.77 – 5.93%) and carbohydrate content (48.04 – 51.07%). The values of phytochemicals assessed were: Tannins (0.54 – 1.65g/100g), phytates (0.13 – 0.49%), oxalates (0.16 – 0.87mg/100g), HCN (0.09 - 0.29mg/100g), Trypsin inhibitor (6.54 and 22.78TIU/mg), alkaloids, flavonoids and saponins were 0.16 – 1.05mg/g, 0.24 – 0.64mg/g and 0.04 – 0.58mg/g respectively. The outcomes of the functional properties' assessment were: Bulk density (0.758 – 0.844g/cm^3), water absorption capacity (3.57 – 4.14ml/g), Oil absorption capacity (1.71 – 1.82ml/g), Foam capacity (18.57 – 23.66%), gelatinization temperature (62.49 – 68.38°C) and viscosity (5.32 – 6.36cP). The results suggest that these plant seeds have potentials for exploitation in domestic/culinary, ethno-medicinal, pharmaceutical and industrial purposes.

Key words: Velvet beans, functional properties, phytochemical analysis, chemical analysis

INTRODUCTION

Food legumes constitute an important part of diet of a larger section of population in the developing world, as a good source of protein, carbohydrates, minerals and vitamins. Being rich in protein, carbohydrate, calorific value, fibre and vitamins, legumes constitute staple food in many countries. Among the wild legumes, the genus

Mucuna is widespread in tropical and subtropical regions of world and is considered as an alternative protein source. *Mucuna pruriens* var. *utilis* (Velvet bean) is an under-utilized legume species grown predominantly in Asia, Africa and in parts of the Americas (Balogun and Olatidoye, 2012).

The plant *Mucuna pruriens*, widely known as "velvet bean," is a vigorous annual climbing legume originally from southern China and eastern India, where it was at one time widely cultivated as a green vegetable crop. It is one of the most popular green crops currently known in the tropics. Velvet beans have great potential as both food and feed as suggested by experiences worldwide. The velvet bean has been traditionally used as a food source by certain ethnic groups in a number of countries. It is cultivated in Asia, America, Africa, and the Pacific Islands, where its pods are used as a vegetable for human consumption, and its young leaves are used as animal fodder (Lampariello *et al.*, 2012).

Velvet bean is considered a rich source of dietary proteins (Rajiv and Chandrashekharaiah, 2017) due to its high protein concentration (23 - 35%) in addition to its digestibility, as compared to other pulses such as soybean, rice bean, and lima bean (Gurumoorthi *et al.*, 2003). However, the beans contain antinutrients, particularly L-DOPA (L-3,4-dihydroxyphenylalanine), that limit their use as a food or feed in humans and non-ruminant animals (Nyirenda *et al.*, 2003).

Mucuna pruriens seeds contain high concentrations of L-DOPA, an unusual non-protein amino acid and a direct precursor to the neurotransmitter *dopamine*, an important brain chemical involved in mood, sexuality and movement. Besides, it also contains some other amino acids, glutathione, lecithin, gallic acid and beta sitosterol. The mature seeds of the plant contain about 3.1 to 6.1% L-DOPA, with trace amounts of 5-hydroxytryptamine (serotonin), nicotine, dimethyl tryptamine (DMT), bufotenine, 5-MeO-DMT and beta-carboline. The leaves contain about 0.5% L-DOPA, 0.006% dimethyl tryptamine and 0.0025% 5-MeO-DMT (Kavitha and Thangamani, 2014). The noxious effects of L-DOPA (e.g. nausea and vomiting) appear to be the most notorious of the antinutritional factors. Traditionally, the L-DOPA is extracted from the beans by leaching and boiling methods, processes that have proven to be rather tedious and laborious, making the high-protein bean unpopular as a food except in times of scarcity or famine ((Nyirenda *et al.*, 2003)). Soaking velvet beans in alkaline solutions of 4% calcium hydroxide ($Ca(OH)_2$) has been found to reduce L-DOPA content to extremely low levels in Mexico (Diallo *et al.*, 2002). However, the black colour of seed processed in this manner makes the beans visually objectionable for human consumption. The most important of these bioactive compounds of plants are alkaloids, flavonoids, tannins, and phenolic compounds. The chemical constituents may be used for the various purposes such as activity against pathogenic bacteria (Yadav *et al.*, 2017).

Functional properties have been defined as those characteristics that govern the behaviour of nutrients in food during processing, storage and preparation as they affect food quality and acceptability. Some important properties that influence the utility of certain foods are water absorption capacity, emulsion capacity, foam stability, viscosity swelling capacity etc. (Onwuka, 2005). Functional properties are the intrinsic physicochemical characteristics which may affect the behaviour of food systems during processing and storage. Adequate knowledge of these physico-chemical properties indicates the usefulness and acceptability for industrial and consumption purposes (Otutu *et al.*, 2015). Functional properties are parameters that determine the application and end use of food materials. This is because diverse food products in the industry are dependent on various functional properties such as dispersibility, water absorption capacity, pasting characteristics, retrogradation, viscosity, swelling power, solubility index (Oluwole *et al.*, 2016). It is integral to consider the chemical, functional and phytochemical characteristics of seeds because they are critical factors for assessing the seeds' edibility and applicability. This work intends to identify the most suitable method for processing velvet bean seeds, diversify the utilization of velvet seeds and add to the body of knowledge on the seeds.

MATERIALS AND METHODS

The mature and dry pods of *Mucuna pruriens* (velvet beans) were purchased from New Market, Aba, Abia State, Nigeria. The reagents used in the analysis were obtained from the Quality Control laboratory of the Department of Food Technology, Federal Polytechnic Nekede, Owerri, where the work was carried out. The reagents used were of analytical grade. The method adopted by Nyirenda *et al.* (2003) was modified and used. The velvet bean seeds were sorted, cleaned and equal portions subjected to different treatments viz; Soaking, fermentation and boiling – all prior to dehulling, drying and milling. The raw seed served as the control. For the first sample, a weight of 2kg of seeds was soaked in potable water twice its volume for 24 hours (fermentation). Thereafter, the seeds were wet-dehulled, boiled for 1 hour and dried to a constant weight at 50°C for 24 hours with frequent turning. The dried seeds were milled using a single disc attrition mill, sieved to obtain fine flour and the resultant flour was packaged in an airtight vessel in readiness for analysis. The vessel was appropriately labelled.

For the second sample, 2kg of seeds was soaked in potable water twice its volume for 12 hours. Afterwards, the seeds were wet-dehulled, boiled for 1 hour and dried to a constant weight at 50°C for 24 hours with frequent turning. The dried seeds were milled using a single disc attrition mill and sieved to obtain fine flour. The resultant flour was packaged in an airtight vessel and properly labelled in readiness for analysis.

For the third sample, 2kg of seeds were boiled for 1 hour, dehulled in potable water and dried to a constant weight at 50°C for 24 hours with frequent turning. The dried seeds were milled using a single disc attrition mill, sieved to obtain fine flour and the resultant flour was packaged in a well-labelled airtight vessel in readiness for analysis.
For the Control, 2kg of seeds was washed and dried to a constant weight at 50°C for 24 hours with frequent turning. The dried seeds were milled using a single disc attrition mill, sieved to obtain fine flour and the resultant flour was packaged in an airtight vessel and labelled in readiness for analysis.

ANALYSIS

Chemical Composition

The chemical compositions of the velvet bean flour samples were determined using the standard methods of the Association of Official Analytical Chemists (AOAC, 2005).

Determination of Functional Properties

The methods of Nzelu *et al.* (2012) and Onwuka (2018) were adopted and used for the determination of the functional properties of the velvet bean flour samples.

Determination of Phytochemicals

The methods described by Kavitha (2018) and Onwuka (2018) were adopted and used for the determination of tannins, flavonoids and phytate content. The method of Uzodinma *et al.* (2018) was used to determine the alkaloids content; while the procedure of Adetuyi (2019) was used for oxalate determination. L-DOPA, hydrogen cyanide and trypsin-inhibitor quantifications were conducted according to the methods stated by Ezeagu *et al.* (2003).

Statistical Analysis

The experimental data generated were subjected to statistical analysis using SPSS 10.00 and MS-Excel at 95% confidence level. T-test was used to compare single test results while the Analysis of Variance (ANOVA) was used for replicate determinations to detect the existence (or otherwise) of significant differences amongst the sample results. For replicate determinations, the mean and standard deviation for each parameter of the experiment were calculated. Duncan's New Multiple Range test was used to separate the means at 5% level of significance. Where applicable, the results are presented as mean ± standard deviation.

RESULTS AND DISCUSSIONS

Table 1: Chemical composition of velvet bean seed flour samples processed by different methods

Sample	Moisture (%)	Crude Protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)	CHO
MCS	9.53^{d}±0.08	23.19^{c}±0.18	6.84±0.01	3.44^{a}±0.02	5.93^{a}±0.01	51.07^{a}±0.14
MBS	10.22^{c}±0.11	24.67^{ab}±0.05	6.81±0.01	3.39^{ab}±0.01	5.82^{b}±0.04	49.09^{b}±0.03
MSS	10.75^{b}±0.03	25.26^{a}±0.54	6.77±0.02	3.34^{b}±0.02	5.84^{ab}±0.05	48.04^{c}±0.56
MFS	11.58^{a}±0.02	24.44^{b}±0.04	6.63±0.01	3.18^{c}±0.02	5.77^{b}±0.02	48.40^{bc}±0.12
LSD	0.52	0.73	-	0.09	0.10	1.01

Values are means ± SD of three replications. Means with different superscripts along a column are significantly different ($p < 0.05$).

MCS = *Mucuna pruriens* Control (Unprocessed); MBS = *Mucuna pruriens* dehulled and boiled for 1hr

MSS = *Mucuna pruriens* Soaked for 12 h, dehulled and boiled for 1 h; LSD = Least Significant difference

MFS = *Mucuna pruriens* Soaked for 24 h, dehulled and boiled for 1 h

Chemical Composition of Velvet Bean Seed Flour Samples Processed by Different Methods

The result of the chemical analysis of velvet bean seed flour samples processed by different methods is shown on Table 1. Significant differences ($p < 0.05$) were observed in moisture, ash, carbohydrate, crude fiber and crude protein content of most of the samples. The moisture content of the flours ranged from 9.53% - 11.58%. The Control sample had the least value (9.53%) while the sample soaked for 24 h had the highest value (11.58%). The values seemed to increase with extended soaking time. The values were similar to the range of values (10.18 – 11.56%) for *Mucuna pruriens* as reported by Kalidass and Mohan (2011), but a little higher than 8.79 – 10.0% reported by Ezeagu *et al.* (2003) for twelve accessions of mucuna. The processing (which resulted in the imbibition of water) and subsequent drying may have influenced the trend.

Crude protein content values ranged from 23.19% - 25.26%. The values lay within the range (22.51 – 27.28%) recorded by Nyirenda *et al.* (2003) for processed and unprocessed velvet beans. The flour sample from the seed soaked for 12h had the highest value (25.26%) whilst the Control sample had the least value (23.19%). Extended soaking prior to boiling seemed to have yielded the most positive outcome on elevated protein content. This observation was in agreement with the findings of Nyirenda *et al.* (2003) that, for samples processed by soaking in water the longest, the process of fermentation resulted in an increase in nutrients, particularly crude protein.

The fat content values were in the range of 6.63 – 6.84%. The Control sample had the highest value (6.84%) whilst the least value (6.63%) was held by the sample soaked for 24 h. The values were within the range of 4.72% - 7.28% crude fat content for twelve accessions of mucuna as reported by Ezeagu *et al.* (2003). The seed is not an oilseed. This is because oilseeds have a crude fat content ranging from 20% to over 40% (Sarwar *et al.*, 2013). However, the value is less than 14.52% reported by Balogun and Olatidoye (2012) for *Mucuna pruriens*.

The ash content of the velvet bean flours ranged from 3.18% - 3.44%. The Control sample had the highest value (3.44%) whilst the least value (3.18%) was held by the sample soaked for 24 h. The outcomes compared favourably with 0.83 – 4.59% reported by Nyirenda *et al.* (2003) for processed and unprocessed velvet beans. Ogbonnaya *et al.* (2010) opined that such decline as a result of soaking and boiling is as a result of leaching of nutrients (ash, in this case) from the seeds into the discarded water.

The crude fibre content of the velvet bean flours was 5.77 – 5.93%. The Control sample had the highest value (5.93%) whilst the least value (5.77%) was held by the sample soaked for 24 h. The range of values was less than 7.23% reported by Balogun and Olatidoye (2012) for *Mucuna pruriens* but more than 3.98% and 1.8% for dehulled raw seeds and processed dehulled mucuna bean seeds respectively as reported by Mugendi *et al.* (2020) – who also agreed that the seed coat was composed mainly of fibre (7.91% in whole raw seeds). The carbohydrate content values were in the range of 48.04 – 51.07%. The least value (48.04%) was held by the sample soaked for 24 h whilst the Control sample had the highest value (51.07%). The values compare well with 46.11% to 52.53% reported by Kalidass and Mohan (2011) for whole, undehulled *Mucuna pruriens* seeds. Most legumes are good sources of carbohydrates (Okaka, 2009). However, soluble carbohydrates are capable of getting drawn into solution and trapped during cooking/dextrinisation (Nzelu *et al.*, 2012).

Table 2: Phytochemical composition of velvet bean seed flour samples processed by different methods.

Sample	Tannins (g/100g)	Phytate (g/100g)	Oxalate (mg/100g)	HCN (mg/100g)	Trypsin Inhibitor (TIU/mg)	Alkaloid (mg/g)	Flavonoid (mg/g)	Saponin (mg/g)	L-DOPA (g/100g)
	Parameters								
MCS	1.65^a±0.11	0.49^a±0.01	0.87^a±0.05	0.29^a±0.02	22.78^a±1.4	1.05^a± 0.2	0.64^a±0.09	0.58^a ±0.2	4.11^a±0.23
MBS	1.21^b±0.14	0.31^b±0.02	0.53^b±0.02	0.22^{ab}± 0.0	18.52^b±1.6	0.71^b± 0.15	0.41^b±0.05	0.33^b ±0.05	2.96^b± 0.15
MSS	1.02^b±0.09	0.28^b±0.00	0.39^b±0.01	0.16^{bc}± 0.0	13.66^c±1.0	0.47^{bc} ±0.1	0.30^{bc}± 0.08	0.13^c± 0.03	2.17^{bc}± 0.11
MFS	0.54^c±0.03	0.13^c±0.01	0.16^c±0.01	0.09^c±0.01	6.54^d±0.65	0.16^c± 0.02	0.24^c±0.01	0.04^c ±0.00	1.25^c±0.12
LSD	0.31	0.08	0.19	0.08	2.09	0.30	0.25	0.18	0.91

Values are means ± SD of three replications. Means with different superscripts along a row are significantly different ($p < 0.05$).
MCS = *Mucuna pruriens* Control (Unprocessed); MBS = *Mucuna pruriens* dehulled and boiled for 1hr
MSS = *Mucuna pruriens* Soaked for 12 h, dehulled and boiled for 1 h; LSD = Least Significant difference
MFS = *Mucuna pruriens* Soaked for 24 h, dehulled and boiled for 1 h

Phytochemical Composition of Velvet Bean Seed Flour Samples Processed by Different Methods

Table 2 displays the phytochemical composition of velvet bean seed flour samples processed by different methods. There were significant differences ($p < 0.05$) across all parameters tested in the different velvet bean flour samples. Also, the control sample had the highest numerical value amongst all the samples assessed; hence, the highest level of phytochemical relative to the other samples.
The tannin content values were in the range of 0.54 – 1.65g/100g. The values contrast slightly with 1.56 - 1.70g/100g reported by Ezeagu *et al.* (2003) for twelve undehulled/unprocessed accessions of mucuna. Treatments significantly ($p < 0.05$) impacted on the concentration of tannins as follows: Control (1.65g/100g), Boiled for 1 h and dehulled

(1.21g/100g), Soaked for 12 h, boiled for 1 h and dehulled (1.02g/100g), and soaked/fermented for 24 h, boiled and dehulled (0.54g/100g). Alonso *et al.* (2000) affirmed that the reduction in tannin contents in dehulled velvet bean relative to the undehulled bean could be linked to high concentration levels of tannins in the seed coat/testa, as infinitesimal quantities of tannins are present in the cotyledons. Tannins are known to inhibit *trypsin*, *chymotrypsin*, *amylase* and *lipase* activities and promote astringent reactions in the oral/buccal cavity at high concentrations (Ohizua *et al.*, 2017); form complexes with proteins, interfere with dietary iron absorption and shown to cause severe growth depression in rats (Onwuka, 2005). Nonetheless, the levels in the extensively processed seeds do not predispose consumers to tannin's adverse effects.

The phytate content ranged between 0.13 – 0.49%. The values obtained from this study were far less than those of Mugendi *et al.* (2020) who reported values of 0.85 and 1.35g/100g for whole and dehulled raw mucuna seeds respectively. Phytates have the anti-nutritional property of lowering the bioavailability of essential minerals and to form complexes with proteins, thereby inhibiting the enzymatic digestion of protein (Kalidass and Mohan, 2011). Phytates were least observed in the sample soaked for 24 h, dehulled and boiled.

The oxalate content was in the range of 0.16 – 0.87mg/100g. The levels were below 1.13 – 2.95mg/100g reported by Ezeagu *et al.* (2003) for twelve mucuna accessions. The values were similar to the range (0.28 – 0.65mg/100g) reported by Ukom *et al.* (2017) for processed (blanched, microwaved, roasted or boiled) and raw cocoyam cormels. They further asserted that boiling causes considerable cell rupture that facilitates the leakage of soluble oxalates into the cooking water. This assertion was proven true in the present study in combination with the extension of soaking time. Onimawo and Akubor (2012) stated that high oxalates content exert a negative impact on nutrient intake by forming insoluble complexes with calcium ions, thus restricting calcium bioavailability.

The level of HCN detected in this study ranged between 0.09 - 0.29mg/100g. This range is lower than 0.24 – 0.38mg/100g reported by Kalidass and Mohan (2011) for five varieties of *Mucuna pruriens*. Ezeagu *et al*. (2003) affirmed that very low cyanide contents have frequently been reported in mucuna. Increased soaking duration with boiling for 1 h effected significant ($p < 0.05$) reductions in cyanide levels (Table 2).

Trypsin inhibitor concentration in the velvet bean flour samples was between 6.54 and 22.78TIU/mg. It compared well with the findings (5.14 and 9.32TIU/mg for raw and dehulled mucuna) of Mugendi *et al.* (2020), but was far less than 40.40 – 48.2TIU/mg reported by Kalidass and Mohan (2011) for five accessions of *Mucuna pruriens*. Onimawo and Akubor (2012) stated that trypsin inhibitors are natural organic compounds which interact with proteolytic enzymes (especially trypsin), rendering them unavailable for protein digestion. They further explained that trypsin inhibitors reduce protein bioavailability and contribute to the poor nutritive quality of human diets, leading to impaired growth, poor food utilization, pancreatic hypertrophy etc. The findings of this study agree with the position of Achinewhu (2011) that overnight soaking (at least) and steaming for 60 minutes destroys trypsin inhibitors and improves the nutritive value better than untreated beans.

The range of values for alkaloids, flavonoids and saponins were 0.16 – 1.05mg/g, 0.24 – 0.64mg/g and 0.04 – 0.58mg/g respectively. There was a generally significant ($p < 0.05$) steady decline in the levels of these antinutrients in the velvet bean flour samples with extended soak time prior to boiling for 1 h (Table 2). Onuegbu *et al*. (2013)

opined that the reduction of antinutritional factors enhance the availability of nutrients, especially minerals, and increase the safety of food products made from them.

For L-DOPA (L-3,4-dihydroxyphenylalanine), the values were 1.25 – 4.11g/100g for the velvet bean flour samples. These values compared well with the values (0.47 – 4.17g/100g) reported by Nyirenda *et al.* (2003) for processed and unprocessed velvet beans. Soaking with subsequent boiling for 1 h yielded a remarkable degree of reduction of the values of L-DOPA (Table 2). This position is supported by Nyirenda *et al.* (2003) who also observed a marked reduction in L-DOPA levels (about 90% decrease from 4.02% to 0.39%) in *Mucuna pruriens* seed grits soaked in water, boiled and soaked for 24 h. L-DOPA is potentially toxic if ingested in large amounts, being implicated in causing hallucinations, gastro-intestinal tract disturbances such as nausea, vomiting and anorexia; as well as being responsible for lowering of protein and starch digestibilities (Kalidass and Mohan, 2011).

Table 3: Functional properties of velvet bean seed flour samples processed by different methods

Sample	BD (g/cm^3)	WAC (ml/g)	OAC (ml/g)	FC (%)	FS (%)	GT (°C)	Viscosity (cP)
MCS	$0.844^a \pm 0.03$	$4.14^a \pm 0.01$	$1.82^a \pm 0.02$	$23.55^a \pm 1.21$	$16.77^a \pm 0.35$	$62.50^d \pm 1.00$	$6.36^a \pm 0.12$
MBS	$0.758^c \pm 0.01$	$3.57^c \pm 0.02$	$1.71^b \pm 0.01$	$18.57^c \pm 0.83$	$12.84^c \pm 0.41$	$68.30^a \pm 0.50$	$5.32^c \pm 0.20$
MSS	$0.785^b \pm 0.03$	$4.14^a \pm 0.02$	$1.82^a \pm 0.05$	$23.66^a \pm 0.56$	$15.41^b \pm 0.21$	$64.00^c \pm 0.50$	$6.33^a \pm 0.14$
MFS	$0.764^c \pm 0.02$	$3.84^b \pm 0.04$	$1.75^{ab} \pm 0.04$	$20.44^b \pm 0.42$	$13.64^c \pm 0.65$	$65.50^b \pm 0.02$	$5.88^b \pm 0.09$
LSD	0.09	0.16	0.10	1.21	1.05	1.17	0.41

Values are means ± SD of three replications. Means with different superscripts along a row are significantly different ($p < 0.05$).

MCS = *Mucuna pruriens* Control (Unprocessed); MBS = *Mucuna pruriens* dehulled and boiled for 1hr
MSS = *Mucuna pruriens* Soaked for 12 h, dehulled and boiled for 1 h; LSD = Least Significant difference
MFS = *Mucuna pruriens* Soaked for 24 h, dehulled and boiled for 1 h
The functional properties of velvet bean seed flour samples processed by different methods are shown on Table 3. There were significant differences ($p < 0.05$) across all parameters tested in the different velvet bean flour samples. The values of bulk density ranged between 0.758 – 0.844g/cm^3. The raw seed flour had the highest value (0.844g/cm^3), whilst the flour from seeds soaked for 12 h prior to cooking had the next highest value of 0.785g/cm^3. The least value of 0.758g/cm^3 was held by the sample just boiled for 1 h without soaking. Bulk density is generally affected by the particle size and the density of flours, which is very important in determining the packaging requirement, raw material handling and application in wet processing in the food industry (Adebowale *et al.*, 2012). The Bulk density values of the flour samples would be useful in the production of bakery and confectionery products.

The water absorption capacity (WAC) of the flour samples ranged from 3.57 – 4.14ml/g. The control and the flour from beans soaked for 12 h before boiling and dehulling had the highest value. The least value was held by the flour from beans which were only boiled for one hour. The trend suggests a steady decline in water uptake by the flour with an increase in soak time despite constant boiling time. The values are in tandem with the 3.21 – 4.71ml/g reported by Nwosu *et al.* (2011) for processed (blanched, cooked or roasted) African yam bean flour. High water absorption capacity is attributed to loose structure which suggests any flour's ability to retain some of the matrix of macro-molecules that has the potential to entrap a large amount of water (Bolarinwa *et al.,* 2015).

The values of Oil absorption capacity (OAC) were 1.71 – 1.82ml/g, with the control and the flour from beans soaked for 12 h before boiling and dehulling having identical peak values (1.82ml/g). These values were higher than the 1.26 – 1.35ml/g reported by Chinma *et al.* (2018) for rice flour. OAC values give an indication of the flour's tendency to maintain or improve mouthfeel if such flour is used as a meat extender (Onuegbu *et al.*, 2013).

Foam capacity values ranged from 18.57 – 23.66%. The flour from velvet beans soaked for 12 h had the highest value (23.66%) and that from beans boiled for one hour had the lowest value (18.57%). The range of values obtained was slightly less than 23.54 – 28.39% reported for flour blends of wheat and Bambara groundnut by Olaoye *et al.* (2018). The foam stability values were in the range of 12.84 – 16.77%. The control sample had the highest value whilst that from beans boiled for one hour and dehulled had the least value. Foam formation and stabiliry are functions of the type of protein, pH, method of processing, viscosity and surface tension (Onimawo and Akubor, 2012). Soaking of seeds exerted some influence on the foamability of the flours. The gelatinization temperature (GT) and viscosity values were 62.49 – 68.38°C and 5.32 – 6.36cP respectively. The highest GT value was held by the flour from beans boiled for one hour and dehulled, whilst the control sample had the least value. Gelatinization temperature implies the temperature at which maximum viscosity can be attained. This results in volume expansion as a result of the degree of cross-linking of the *amylopectin* and the concentration of the starchy matter (Wikipedia, 2018). The higher the starch content of flour, the lower the GT (Chandra *et al.*, 2014). In terms of viscosity, the control sample had the highest value (6.36cP) whilst that from beans boiled for one hour and dehulled had the least value (5.32cP). These values vary widely from 2.8 – 12.30cP reported for processed (blanched, cooked or roasted) African yam bean flour by Nwosu *et al.* (2011). Viscosity is an important functional property that affects mouthfeel and textural quality of fluid foods such as beverages and batters (Nwosu *et al.,* 2011).

CONCLUSION

The effects of different processing techniques on the chemical, functional and phytochemical properties of *Mucuna pruriens* seed flours were successfully investigated. The findings revealed a significant impact on the bioavailability of nutrients (both in terms of nutrient potential and reduction of antinutrient levels) with extended soaking time of seeds – even up to 24 h prior to boiling and dehulling. The functional properties indicated that the seed flours possess desirable attributes. These may be exploited in food formulation drives, especially in baking and confectionery applications involving composite flours.

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