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Full Length Research Paper

Functional and physicochemical properties of flours of six *Mucuna* species

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Legume flours were prepared from six species of mucuna bean, *M. Veracruz* mottle, *M. rajada, M. cochinchinensis, M. deerigeana, M. pruriens* and *M. veracruz* white. Physicochemical and functional characteristics were carried out on full fat and defatted flours. Bulk density of the flours increased following defatting. Isoelectric point of the proteins lies between 4 and 5. Generally, solubility reduced as the pH increases until it reached isoelectric point, followed by progressive increase in solubility with further increase in pH. Defatted flours have higher water and oil absorption capacities compared with full fat samples and *M. veracruz* white recorded the lowest value (1.40 g/g) while *M. veracruz* mottle had the highest value (2.20 g/g). Gelation studies revealed that *M. veracruz mottle* and *M. rajada* recorded the highest values (20%) while *M. veracruz* white and *M. deerigeana* had the lowest value (14%). The foaming capacity in full fat flours ranged between 9.6% in *M. veracruz* white and 19.23% in *M. pruriens* while the foaming capacity in defatted flours ranged from 50.0% in both *M. pruriens* and *M. veracruz* white and 84.30% in *M. veracruz* mottle. In addition, foaming capacities in full fat flours are lower than those of defatted flours. Emulsion capacity ranged between 78-90% in full fat flours and 56-68% in defatted flours.

Key words: Mucuna, flours, functional properties.

INTRODUCTION

The wide prevalence of protein-calories malnutrition in developing countries is of great importance not only to food scientists, nutritionists or agricultural scientists but also for concerned governments as well (Olsen, 1975). The continuous increase in population and inadequate supply of protein has inadvertently increased the occurrence of malnutrition in developing countries (Siddhuraju, 1996). Recent studies have shown that malnutrition among children in developing countries is mainly due to the consumption of cereal based porridge which is bulky, low in energy and density and high in anti-nutrients (Michaelsen and Henrik, 1998). Plant protein products are gaining increased interest as ingredients in food systems throughout many parts of the world; the success of utilizing plant proteins as additives depends greatly upon the favourable characteristics that they impart to foods. In the developed countries, plant proteins are now either regarded as versatile functional ingredients or as biologically active components more than as essential nutrients (Marcello and Gius, 1997). The partial replacement of animal foods with legumes has been shown to improve nutritional status (Guillion and Champ, 1966) due to lower cholesterol level in plant foods. Also, plant food diets increase the level of fibre intake which reduces the risk of bowel diseases, including cancer and also reduction in osteoporosis incidence (Strtori and Lovati, 2001). This evolution towards health and functionality is mainly driven by the demands of consumers and health professionals. The partial replacement of animal foods with legumes is claimed to improve overall nutritional status (Guillion and Champ, 1996).

Mucuna bean is one of the underutilized legumes in Africa. The seed is not only rich in proteins but also in carbohydrates, fats, mineral and other nutrients. The

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seeds of mucuna beans (*Mucuna pruriens*) are less exploited as protein source in Africa. They are traditionnally used as soup thickener by Ibos in south-eastern Nigeria. Outside Africa, the seeds are also eaten by Indian tribal sects, Mundari and Dravidian groups.

In an earlier work, we have presented the variability in the chemical composition, amino acids and antinutrients of six varieties of *Mucuna* (Adebowale et al., 2005). Therefore in continuation of our studies on these underutilised tropical legumes, this article considers the functional properties of full fat and defatted flours of six *Mucuna* species. The output of the research involves the collation of the data on the functional and physicochemical properties of the mucuna bean flours. This would provide useful information to industrialists and others alike on the subsequent incorporation of the *Mucuna* species into food products to produce natural, cheap and adaptable functional foods.

MATERIALS AND METHODS

Materials

Six species of mucuna beans seeds namely: *M. Veracruz* mottle, *M. rajada, M. cochinchinensis, M. deerigeana, M. pruriens* and *M. veracruz* white were obtained from the International Institute for Tropical Agriculture, Ibadan. All chemicals used were of analytical grade.

Preparation of flours

Cleaned seeds of mucuna seeds were dehulled with a hammer mill followed by winnowing of the seed coats. The dehulled seeds from each legume species were then milled into flour in a hammer mill. They were ground to pass through a BS 60 mesh screen. The samples were then kept in the refrigerator at 4°C prior use. A potion of the flour was defatted by extracting with n-hexane in a soxhlet extractor for 9 h. The full fat and defatted samples were then used for the analysis.

Determination of bulk density

This was carried out using the procedure of Narayana and Narasinga (1984). A specified quantity of the flour sample was transferred into an already weighed measuring cylinder (w_1). For the packed bulk density determination, the flour sample was gently tapped to eliminate spaces between the flour and the level was noted to be the volume of the sample and then weighed (W_2). No tapping was made in the case of loosed bulk density and the level was also noted to be the volume of the sample and then weighed. The study was conducted in triplicate.

$$\text{Bulk density (g/cm}^3\text{)} = \frac{W_2 - W_1}{\text{Vol. of Sample}}$$

Protein solubility

Protein solubility was determined by the method of Sathe et al. (1982) with some modifications. The suspensions (0.2%) of the flour in distilled water were adjusted to pH 2-11 using 1 M HCl and 1 M NaOH. The amount of nitrogen in each supernatant was determined by micro Kjedahl method according to the method already described in the AOAC (1990). Percent soluble protein was calculated as percent nitrogen multiplied by 6.25 on wet basis.

Determination of water and oil absorption capacity

Water absorption capacity was determined using the method of Sathe and Salunkhe (1981) with slight modifications. 10 mL of distilled water was added to 1.0 g of the sample in a beaker. The suspension was stirred using a magnetic stirrer for 5 min. The suspension obtained was thereafter centrifuged at 3555 rpm for 30 min and the supernatant measured in a 10 mL graduated cylinder. The density of water was taken as 1.0 g/cm^3. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant. The same procedure was repeated for oil absorption except that oil was used instead of water.

Determination of the gelation concentration

The least gelation concentration was determined by the method of Sathe et al. (1981). Test tubes containing suspensions of 2, 4, 6, 8 up to 20% (w/v) flour in 5 ml distilled were heated for 1 h in boiling water, followed by cooling in ice and further cooling for 2 h at 4°C. The least gelation concentration was the one at which the sample did not fall down or slip when the test tube was inverted.

Determination of foaming properties

The foam capacity and stability were studied by the method of Coffman and Garcia (1977). A known weight of the mucuna sample was dispersed in 100 mL distilled water. The resulting solution was homogenized for 5 min at high speed. The volume of foam separated was noted. The total volume remaining at interval of 0.00, 0.30, 1, 2, 3, 4 up to 24 h was noted for the study of foaming stability.

$$\%\ \text{Foaming capacity} = \frac{\text{vol. after homogenization} - \text{vol. before homogenization}}{\text{vol. before homogenisation}} \times \frac{100}{1}$$

$$\%\ \text{Foam stability} = \frac{\text{foam volume after time (t)}}{\text{Initial foam volume}} \times \frac{100}{1}$$

The effect of pH on foaming properties was carried out by adjusting 2% (w/v) dispersion to the desired pH range from 2 to 11 using either 1 M HCl or NaOH followed by vigorous whipping as described above.

Emulsion capacity and stability

Emulsions were formed inside a 600 ml beaker using a continuous stirring apparatus. The apparatus consisted of a regulated/stabilised 6 V power supply, a burrette, a stirrer, a beaker with emulsion and a digital milliameter. The stirrer was made up of stainless steel rod holding a Perspex bridge was fixed to a 6 V D.C motor spindle by means of a plastic adaptor. The motor itself was driven by a regulated and stabilized 6 V D.C power supply. The milliameter monitored the current drop by the stirrer motor to maintain a constant speed. The greater the viscosity of the emulsion, the greater will be the current drawn. The protein sample (0.25, 0.5, 0.75, 1.00 and 1.25 g) was dissolved in 25 ml of distilled water making 1, 2, 3, 4 and 5% slurries (w/v), respectively.

Table1. Bulk density of full fat and defatted mucuna flours*

Sample	Bulk density (g/cm^3)	
	Full fat	Defatted
Mucuna vera cruz mottle	0.51±0.02	0.80±0.04
Mucuna rajada	0.61 ±0.04	0.88±0.05
Mucuna cochinchinensis	0.50±0.03	0.80±0.04
Mucuna deerigeana	0.42±0.03	0.74±0.05
Mucuna pruriens	0.54±0.04	0.72±0.04
Mucuna vera cruz white	0.60±0.02	0.84±0.05

* Mean ±SD of three replicate determinations

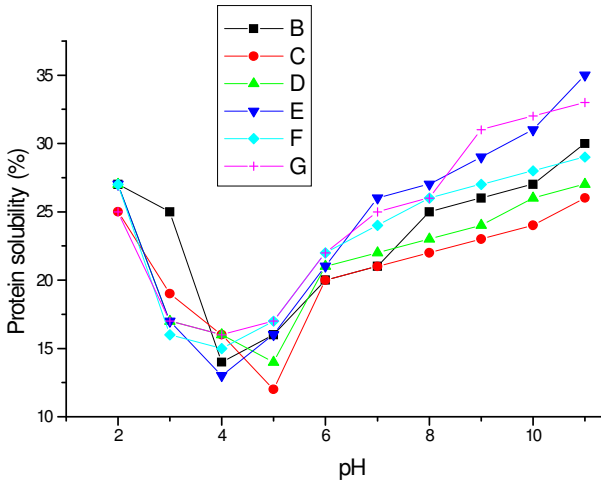


Figure 1. Protein solubility of mucuna flours. **B.** *M. veracruz* mottle, **C.** *M. rajada*, **D.** *M cochinchinensis*, **E.** *M. deerigeana*, **F.** *M. pruriens* and **G.** *M. veracruz* white.

Necessary pH adjustment was made to ensure maximum solubilisation of the protein. The mixture was stirred for 30 min in order to disperse the sample. Oil was then added at a rate of 1.00 ml/s from a burette until emulsion collapsed indicated by a sharp fall in motor current. The volume of oil added up to inversion point was noted and the emulsion capacity expressed as ml oil per g of sample. The emulsion stability was determined by allowing the emulsion prepared to stand in a graduated cylinder and the volume of oil separated at time of 0.00, 0.5, 1, 2, 3 up to 24 h was noted in each case. The emulsion stability was determined by following the procedure used for emulsion capacity except that 100 ml of oil was added rather than adding oil until the emulsion breakdown.

$$\% \text{ emulsion stability} = \frac{\text{Height of the emulsified layer}}{\text{Height of the total content}} \times \frac{100}{1}$$

Statistical analysis

All experiments in this study are reported as mean of three replicate analyses. One way analysis of variance (ANOVA) was carried out to compare between the mean values of different species of the seeds. Differences in the mean values were determined at $P < 0.05$ (SAS, 1990).

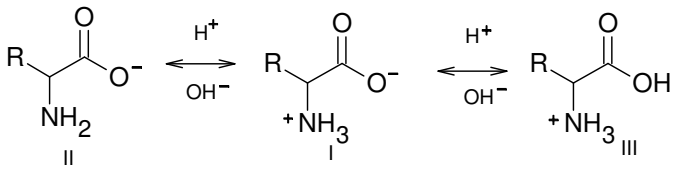
RESULTS AND DISCUSSION

Bulk density

The results of bulk densities of full fat and defatted flours are presented in Table 1. The results obtained indicate that bulk density increased following defatting of flours. The values obtained ranged from 0.42 to 0.61 g/cm^3 in full fat flours and 0.72 to 0.88 g/cm^3 in deffated flours. Similar results were reported by Chau and Cheung (1997) in their studies of another legume, *Dolichos lablab*. High bulk density of the *Mucuna* species indicates that they would serve as good thickeners in food products.

Protein solubility

pH dependent protein solubility profile of flours are presented in Figure 1. Isoelectric point of the proteins was between pH value 4 and 5. Generally, solubility reduced as the pH increased until it reached isoelectric point, followed by progressive increase in solubility with further increase in pH. Similar observations have been presented earlier by Sathe et al. (1982) for winged bean. Prevalent charge on the constituent amino acids of proteins at various pH values determine protein solubility as follows:



It is a zwitterion or dipolar ion which predominates at the region of isoelectric point in protein. At this pH, minimum solubility takes place because of minimum repulsion among the constituent amino acids. The balance in positive and negative charges minimised the

Table 2. Water and Oil absorption capacity of full fat and defatted mucuna flours.

Sample	Full fat		Defatted	
	WAC	OAC	WAC	OAC
M. vera cruz mottle	2.00±0.06^{c}	2.00±0.06^{d}	2.20±0.06^{d}	2.10±0.06^{a}
M. rajada	1.20±0.04^{a}	2.20±0.58^{d}	1.70±0.05^{bc}	2.50±0.07^{bc}
M. cochinchinensis	1.20±0.04^{a}	2.00±0.06^{c}	1.60±0.05^{b}	2.30±0.07^{ab}
M. deeringeana	1.60±0.05^{b}	2.30±0.07^{a}	1.72±0.05^{bc}	2.40±0.07^{bc}
M. pruriens	1.50±0.04^{b}	2.25±0.07^{b}	1.80±0.05^{c}	2.60±0.07^{c}
M. vera cruz white	1.20±0.04^{a}	2.40±0.07^{a}	1.40±0.04^{a}	2.60±0.08^{c}

* Mean ±SD of three replicate determinations
WAC water absorption capacity
OAC Oil absorption capacity

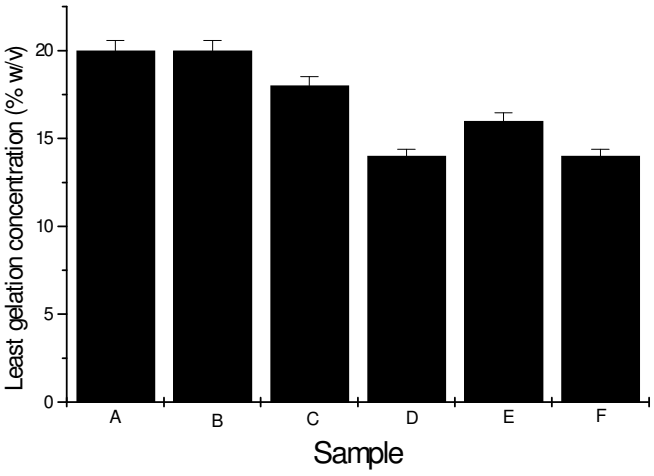


Figure 2. Least gelation concentration of mucuna flours. **A.** *M. veracruz* mottle, **B.** *M. rajada*, **C.** *M. cochinchinensis*, **D.** *M. deerigeana*, E. *M. pruriens* and F. *M. veracruz* white.

electrostatic repulsion, and this reduced solubility of proteins at isoelectric pH. When pH of the solution reduced further, cation III predominates while in alkaline medium, anion II takes preponderance. In both cases, electrostatic repulsion improved and this enhanced solubility as it is observed in pH 2 and 11. The high solubility of these flours in the acidic pH range indicates that these flours may be useful in the formulation of acidic food like protein rich carbonated beverages (Kinsella, 1979). Since protein solubility largely affects other functionalities like emulsification, foaming and gelation (Kinsella, 1976), the high solubility of the proteins indicate that they could have promising food applications.

Water/oil absorption capacities

The results of water and oil absorption capacities are presented in Table 2. The water absorption capacities ranged between 1.2 to 2.00 g/g for full fat and 1.40 to 2.20 g/g for defatted flours, respectively. Defatted flours have higher water and oil absorption capacities compared with full fat samples. The results indicate that *M. veracruz* white recorded the lowest value (1.40 g/g) while *M. veracruz* mottle had the highest value (2.20 g/g). The removal of fat from the samples exposes the water binding sites on the side chain groups of protein units previously blocked in a lipophilic environment thereby leading to an increase in WAC values in defatted flours. Similar observation has been reported by Lin et al. (1974) on sunflower meal products. Water absorption capacity is a critical function of protein various food products like soups, gravies, doughs and baked products (Sosulski et al., 1976). Mucuna bean could be useful in these formulations. Oil absorption capacities ranged from 2.00 to 2.40 g/g for full fat and 2.10 to 2.60 g/g in defatted samples. *M. veracruz* white recorded the highest oil absorption capacity (2.60 g/g) while *M. veracruz* mottle had the lowest value (2.1 g/g). It was observed that the oil absorption capacity of deffated samples was better than full fat samples. These values compared favourably with oil absorption capacity reported for African yam bean by Oshodi et al. (1997). Lower values were recorded by Oshodi and Fagbemi (1992) in their work on pumpkin seeds. Also the oil absorption capacity values obtained in this work is higher than the values obtained for pigeon pea (Oshodi and Ekperigin, 1989). Liquid retention is an index of the ability of proteins to absorb and retain oil/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 (Cheftel et al., 1985; Okezie and Bello, 1988). Mucuna bean would therefore be useful as a flavour retainer in certain food products.

Least gelation concentration

The least gelation concentration for full fat mucuna flours is presented in Figure 2. It ranged from 14 to 20%. *M. veracruz* mottle and *M. rajada* recorded the highest values (20%) while *M. veracruz* white and *M. deerigeana* had the lowest value (14%). These values compared

Table 3. Foaming capacity and stability of full fat Mucuna sp

Mucuna sp	Foaming Capacity (%)	0.5 hour	1hour	2hours	4hours	6hours	10 hours	24 hours
M. vera cruz mottle	15.4 ±0.4^{b}	60.0±1.7	60.0±1.7^{b}	60.0±1.7^{c}	56.0±1.6^{ab}	56.0±1.6^{ab}	52.0±1.5^{a}	52.0±1.5^{a}
M. rajada	9.80±0.3^{a}	56.0±1.6	56.0±1.6^{ab}	56.0±1.6^{abc}	56.0±1.6^{ab}	54.0±1.6^{a}	54.0±1.6^{a}	52.0±1.5^{a}
M. cochinchinensis	15.7±0.5^{b}	59.0±1.7	59.0±1.7^{ab}	59.0±1.7^{bc}	57.0±1.6^{ab}	56.0±1.6^{ab}	53.0±1.5^{a}	51.0±1.5^{a}
M. deerigeana	17.7±0.5^{c}	57.0±1.6	56.0±1.6^{ab}	54.0±1.6^{ab}	52.0±1.5^{a}	51.0±1.5^{a}	51.0±1.5^{a}	51.0±1.5^{a}
M. pruriens	19.2±0.6^{d}	61.0±1.8	61.0±1.8^{b}	61.0±1.8^{c}	61.0±1.8^{b}	61.0±1.8^{b}	60.0±1.7^{b}	53.0±1.5^{b}
M. veracruz white	9.60±0.3^{a}	57.0±1.6	54.0±1.6^{a}	53.0±1.5^{a}	52.0±1.5^{a}	52.0±1.0^{a}	52.0±0.9^{a}	52.0±0.6^{a}

* Mean ±SD of three replicate determinations.
Means within columns with different letters are significantly different (P≤ 0.05).

Table 4. Foaming capacity and stability of defatted Mucuna sp

Mucuna sp	Foaming Capacity (%)	0.5 hour	1hour	2hours	4hours	6hours	10 hours	24 hours
M. vera cruz mottle	84.3±2.4^{d}	94.0±2.7^{d}	94.0±2.7^{c}	92.0±2.7^{c}	90.0±2.6^{d}	90.0±2.6^{c}	76.0±2.2^{c}	70.0±2.0^{b}
M. rajada	66.7±1.9^{b}	85.0±2.5^{b}	85.0±2.5^{b}	82.0±2.4^{b}	80.0±2.3^{c}	80.0±2.3^{d}	70.0±2.0^{c}	66.0±1.9^{b}
M. cochinchinensis	73.1±2.1^{c}	76.0±2.2^{a}	74.0±2.1^{a}	72.0±2.1^{a}	72.0±2.1^{b}	70.0±2.0^{c}	70.0±2.0^{c}	56.0±1.6^{a}
M. deerigeana	73.1±2.1^{c}	90.0±2.6^{d}	74.0±2.1^{a}	70.0±2.0^{a}	70.0±2.0^{b}	66.0±1.9^{b}	62.0±1.8^{b}	52.0±1.5^{a}
M. pruriens	50.0±1.4^{a}	74.0±2.1^{a}	72.0±2.1^{a}	70.0±2.0^{a}	68.0±2.0^{b}	62.0±1.8^{ab}	62.0±1.8^{b}	54.0±1.6^{a}
M. veracruz white	50.0±1.4^{a}	74.0±2.1^{a}	72.0±2.1^{a}	68.0±2.0^{a}	62.0±1.7^{a}	56.0±1.6^{a}	54.0±1.6^{a}	52.0±1.5^{a}

* Mean ±SD of three replicate determinations.
Means within columns with different letters are significantly different (P≤ 0.05).

favourably with those reported for African yam bean (16 to 20% by Abbey and Ayuk (1991), raw cowpea flour (Abbey and Ibeh, 1987) and winged bean flour (Sathe et al., 1982). However lower values were recorded for several *Phaseolus* species and lablab beans by Chau and Cheung (1998) and Deshpande et al. (1982). Sathe et al. (1983) also reported a least gelation concentration of 12% for black gram flour. Sathe et al. (1982) have associated the variation in gelling properties to the ratio of different constituents such as protein, lipids and carbohydrates in different legumes. Moreover, Flemming et al. (1975) suggested a direct correlation between least gelation concentration and the level of globulin in legume seeds.

Gelation properties are interrelated to water absorption capacities hence the low water absorption capacity recorded by the flours could explain the deficient gel formation capacity. 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. (1997). The high least gelation concentration observed in the *Mucuna* species may be a disadvantage for its use in the production of curd and cheese (Altschul and Wilcke, 1985).

Foaming properties

The results of foaming capacity and foam stability are shown in Tables 3 and 4. The foaming capacity in full fat flours ranged between 9.6% in *M. veracruz* white and 19.23% in *M. pruriens* while the foaming capacity in defatted flours ranged from 50.0% in both *M. pruriens* and *M. veracruz* white and 84.30% in *M. veracruz* mottle.

The foaming capacities in full fat flours are lower than those of defatted flours. Defatting markedly increase the foaming capacity in the flours. The foaming capacity recorded in in defatted flours is higher than those recorded for pumpkin flavours (13.2%) by Oshodi and Fagbemi (1992), and defatted cowpea flour (40%) reported by Abbey and Ibeh (1988). It was reported that foamability is related to the rate of decrease of the surface tension of the air/water interface caused by absorption of protein molecules (Sathe et al., 1982). Graham and Phillips (1976) linked good foamability with flexible protein molecules, which reduces surface tension. Low foamability on the other hand can be related to highly ordered globular proteins, which resists surface denaturation. The basic requirements of proteins as good foaming agents are the ability to (i) adsorb rapidly at air-water interface during bubbling, (ii) undergo rapid conformational change and rearrangement at the interface, and (iii) form a cohesive viscoelastic film via intermolecular interactions. The first two factors are essential for better foamability whereas the third is important for the stability of the foam. The foam stability ranged from 7.5 – 17.31 at 4 h for full fat flours and 26.92 to 73.10 at 4 h for defatted flours as indicted in Figures 3 and 4. The success of whipping agents largely depends on how long the whip can be maintained. Oil seed

proteins have recently found increasing use as aerating agents in whipped toppings, frozen desserts and angel food and sponge cakes. Defatted mucuna flours could be utilized for these food products in view of their good foaming properties.

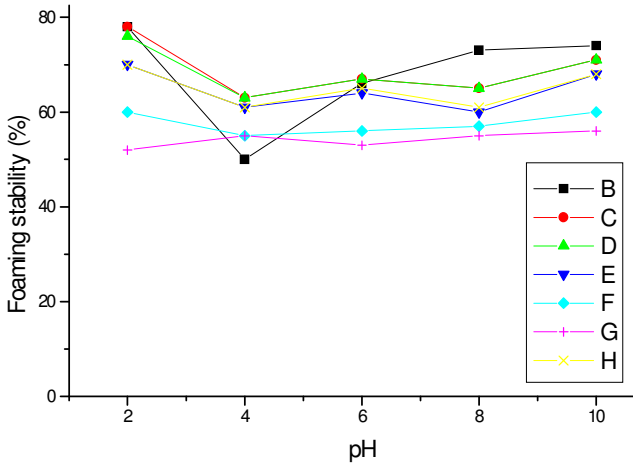


Figure 3. Effect of pH on the foaming stability of *M. veracruz* mottle. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

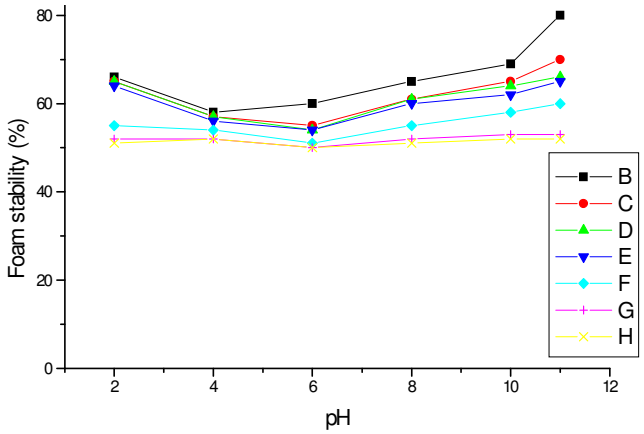


Figure 4. Effect of pH on the foaming stability of *M. rajada*. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

Effect of pH on foaming capacity and solubility

The result of the effect of pH on foaming stability is presented in Figures 3 to 8. The pattern of foamability response to pH was similar to the pattern of solubility profile. All the flour samples showed minimum foamability at pH 4. Maximum capacity was recorded at pH 11 while increase in foaming capacity was observed at pH 2. The foaming capacity at alkaline region was however higher than the value obtained at pH 2. Foams of all the flours were more stable at the acidic pH range than in the

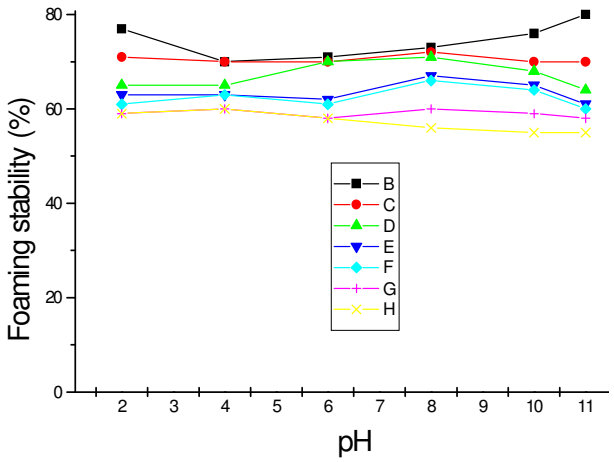


Figure 5. Effect of pH on the foaming stability of *M. veracruz* white. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

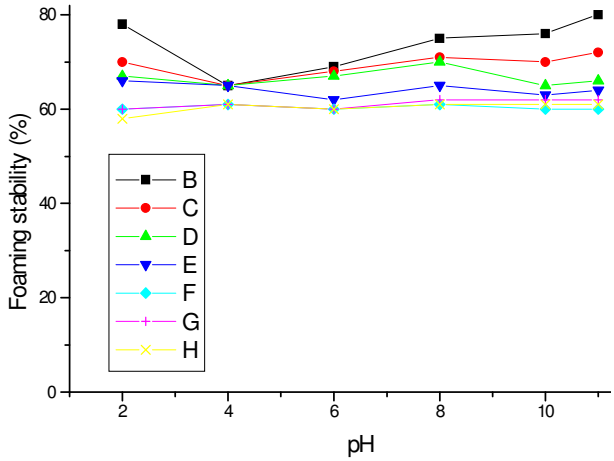


Figure 6. Effect of pH on the foaming stability of *M. pruriens*. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

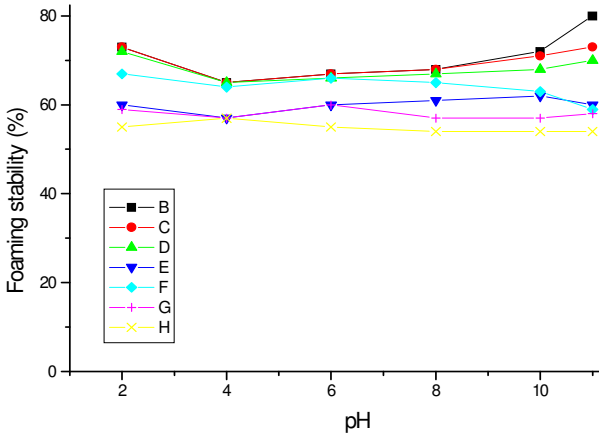


Figure 7. Effect of pH on the foaming stability of *M. cochichinensis*. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

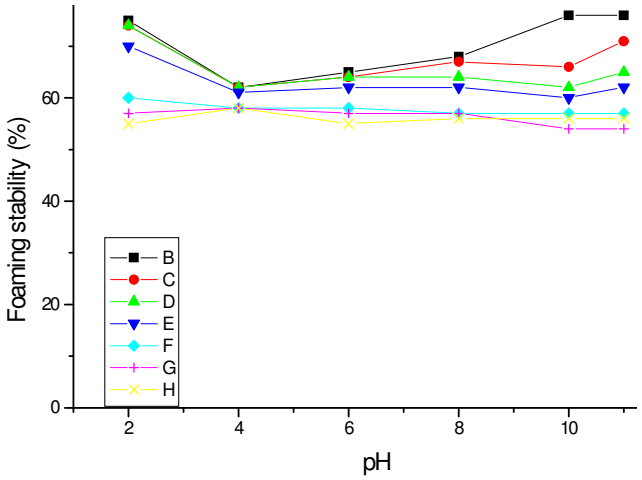


Figure 8. Effect of pH on the foaming stability of *M. deerigeana*. **B.** 0.5 h, **C.** 1 h, **D.** 2 h, **E.** 4 h, **F.** 5 h, **G.** 10 h, **H.** 24 h.

alkaline pH region. After 24 h the highest foam stability was observed at pH 4 while the least value was recorded at pH 11. Earlier workers (Sathe et al., 1982; Linn et al., 1974; Aluko and Yada, 1995) reported a pH dependency of foaming capacity and stability in lupin, winged bean, sunflower and cowpea seed proteins. The better stability of the foams in the acidic pH range might be attributed to the formation of stable molecular layers in the acidic pH range, which contributes to the foam stability and elasticity. Since the foam stability is governed by the ability of the film around the entrapped air bubbles to remain intact, the poor foam stability at alkaline pH region indicates a positive correlation between alkalinity and surface activity.

Table 5. Emulsion capacity of full fat and defatted mucuna flours*.

Sample	Emulsion capacity (%)	
	Full fat	Defatted
Mucuna vera cruz mottle	80 ± 5.1	68 ± 3.4
Mucuna rajada	84 ± 4.0	56 ± 4.0
Mucuna cochinchinensis	78 ± 3.3	62 ± 3.5
Mucuna deerigeana	90 ± 4.0	66 ± 3.2
Mucuna pruriens	80 ± 4.5	60 ± 2.9
Mucuna vera cruz white	86 ± 5.0	60 ± 2.9

Mean ± SD of three replicate determinations.

Emulsion capacity

The result of emulsion capacity for full fat and defatted samples are presented in Table 5. It ranged between 78 to 90% in full fat flours and 56 to 68% in defatted flours. These flours compared favourably with the values reported for *Citrullus vulgaris* varieties (Ige et al., 1984) but higher than the values reported by Oshodi and Fagbemi (1992) for defatted pumpkin flour. The emulsifying properties of oil seed proteins have been discussed by various authors (Mcwaters and Holmes, 1979; Cherry and Mcwaters, 1989). The properties are influenced by many factors among which are solubility, pH and concentration. The capacity of protein to enhance the formation and stabilization of emulsions is important for many applications in food products like cake, coffee whitners and frozen desserts. In these products, varying emulsifying and stabilizing capacity are required because of the different compositions and stresses to which these products are subjected. In view of the high emulsion capacity of the mucuna flours, it could be used as additives for the stabilization of emulsions in soups and cakes.

CONCLUSIONS

It has been shown, through detailed characterisation of the functional properties, that the mucuna bean flours possess high water and oil absorption capacities. They could therefore be potentially useful in flavour retention, improvement of palatability and extension of shelf life in meat products. The foaming capacity and stability in the flour were also higher than for most other legumes. Since foam contributes to smoothness, lightness, flavour dispersions and palatability, the results obtained from the current study indicate that the samples, could serve as potential replacements of known proteins in food applications requiring high foamability and stability, for example, cakes, breads, marshmallow, whippings, toppings, ice creams and desserts. Finally, the high emulsion activity and stability of the mucuna flours indicates that they could be used as ingredients in many food formulations such as salad dressing, comminuted meats, ice creams, cake batters and mayonnaise. Considering the overall functional properties of Mucuna bean flours, the species should be an economic and alternative protein source with great potential to alleviate protein malnutrition in developing countries and to improve the overall nutritional status of functional foods in the developed countries.

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