



Potentials of Defatted *Mucuna sloanei* (UKPO) Seed Flour as Boon for Human Nutrition and Healthy Food Alternative

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Authors' contributions

This work was carried out in collaboration among all authors. Author GOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SGO, OAA and AAA managed the analyses of the study. Authors IAA and EOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Functional, antinutritional, antioxidant and elemental compositions of full-fat sample (FFS) and defatted sample (DFS) *Mucuna sloanei* (Ukpo) seed were investigated using standard analytical techniques. The results of functional properties (%) in full fat and defatted seed flours were as follows; foaming capacity (6.00 ± 0.04 and 30.30 ± 0.15), foaming stability (1.10 ± 0.00 and 24.00 ± 0.20), water absorption capacity (50.00 ± 0.05 and 70.00 ± 0.05), oil absorption capacity (19.50 ± 0.50 and 21.75 ± 0.15), emulsion capacity (41.58 ± 0.14 and 44.12 ± 0.08), emulsion stability (39.61 ± 0.23 and 34.31 ± 0.11), least gelation concentration (0.03 ± 0.00 and 0.10 ± 0.00) g/cm³ and bulk density (0.77 ± 0.01 and 0.91 ± 0.00) g/cm³ respectively. The antinutrient analysis of full fat and defatted seed flours in mg/g showed glycoside with the highest value to be (23.60 ± 0.13 and 41.18 ± 0.05), phytic acid (20.15 ± 0.07 and 13.15 ± 0.07), oxalate (7.11 ± 0.02 and 0.47 ± 0.12), phytin P (5.68 ± 0.38 and 3.70 ± 0.14) and tannins (0.37 ± 0.01 and 0.47 ± 0.02). Potassium

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was found to give higher values in the two samples with defatted sample having the highest value. The antioxidant analysis of the full fat and defatted seed flours showed DPPH to be (33.08 ± 0.06 and 35.13 ± 0.03) %, FRAP (48.93 ± 0.11 and 49.03 ± 0.08) mg/g, phenol (4.16 ± 0.07 and 5.28 ± 0.06) % and flavonoid (8.28 ± 0.00 and 3.68 ± 0.10) % respectively. From this nutritional assessment, defatted seed flour of *M. sloanei* could be described as a good food that can be used to supplement the existing food table in the fight against protein - malnutrition syndrome among the developing countries of the world.

Keywords: *Mucuna sloanei*; full-fat; defatted; antinutrient; antioxidant; protein-malnutrition.

1. INTRODUCTION

Consistent consumption of foods that contain significant levels of phytochemicals and dietary fiber correlates with tangible health benefits. Awika et al. [1] posited that it is important to enhance the consumption of healthy food by increasing the variety of food rich in beneficial compounds and improving technology to enhance their organoleptic appeal. The use of plants for food and drug could be traced to the early days of man on earth and the use of plants for medicine is popular in all countries of the world [2]. Most tropical plants yield edible fruits whose seeds are not consumed due to lack of information about them. One possible way of achieving nutrition security in developing countries is through exploitation and utilization of available foods sources and resources [3,4]. Plant seeds are good source of food for man and animals. These edible seeds such as cereals, legumes and nuts [5] contain nutrients necessary for man growth such as fats in form of omega fats. Vegetable proteins have been reported to be economical and sustainable alternatives for animal proteins as functional ingredients in food formulations [6].

Most countries especially developing ones do not produce enough food of the right nutritional quality to meet daily needs of their ever growing population [7]; therefore it is very important to exploit other less utilized plant seeds to increase the number of available food materials from plant source as well as combating protein-energy malnutrition among low income earners. *M. sloanei* which is popularly known as Ukpo by the Ibo-speaking people of the South-eastern Nigeria is a leguminous plant that belongs to sub family fabaceae. Its seeds are covered with brownish dense whisker-like hairs called trichomes that can be extremely painful when they get to one's eyes or cause itchy blister when they come in contact with the skin [8]. These characteristics

have greatly affected its usage in the edible food table. These seeds are cooked or soaked overnight, cracked by hitting with a hard object, dehulled, ground into fine powder and finally mixed with red palm oil before marketing as soup thickener. The seed is diuretic as well as purgative and are also used as soothing medicine to relieve the discomfort of hemorrhoids. Oil extracted from the seed can be used in preparation of resin, paint, polish, wood varnish, skin cream and for soap production. *M. Sloanei* seeds have protein, carbohydrate, crude fat and fiber contents [9]. Potentials of several seeds have been reported [4,10,11]. Different processing methods such as fermentation, cooking and dehulling were documented by Obiakor-Okeke and Anozie [8] as means of improving nutrient composition of *M. sloanei* seed. Reducing fat in every-day diet is widespread as increased fat content has become a public health issue and a concern for most consumers [12].

Reports on the effect of defatting on the seed composition were found to be scanty in literature; therefore this research work documents our findings on the effect of defatting process on the chemical composition of *M. sloanei* seed flour as a potential means of developing the seed into a good food supplement and a successful reduced fat alternative.

2. MATERIALS AND METHODS

2.1 Materials

Freshly harvested *M. sloanei* seeds were bought at Oyingbo market, Lagos State, Nigeria. The seeds were brought to the Science Laboratory of Osun State Polytechnic, Iree where they were identified by a Biologist as *Mucuna sloanei*. The seed with the specimen number of SP/297 given to it were deposited in the herbarium unit of the laboratory for further reference.

2.1.1 Sample pre-treatment

The seeds were cracked open, sun-dried for two weeks, pulverized and passed through a 2 mm sieve to obtain fine powder that was divided into two parts. One part was used as control while the other part was defatted in a soxhlet extractor using n-hexane as the extractant. Two grams of the sample was weighed in a pre-weighed filter paper that was inserted into a soxhlet apparatus where extraction was carried out for 6 h using n hexane at 60°C. At the end of the extraction, the residue in the filter paper was allowed to cool to room temperature and stored in a dessicator ready for further analysis.

2.2 Methods

The mineral content of the full fat and defatted seed flours for sodium, potassium, calcium, magnesium and iron were determined by the methods of AOAC. [13], functional properties for bulk density (BD) and least gelation concentration (LGC) were determined by the methods of Otutu et al. [4], water absorption capacity (WAC) and oil absorption capacity (OAC) were analyzed using the methods highlighted by Osundahunsi, [14] while the emulsion stability (ES), emulsifying capacity (EC), foam stability (FS), foam capacity (FC) as well as anti-nutrient and antioxidants compositions of the seed flours were determined using the methods of AOAC, [15].

3. RESULTS AND DISCUSSION

3.1 Discussion

3.1.1 Elemental composition of *M. sloanei* seed flours

The results of the elemental composition revealed that defatting has increased the contents of potassium, magnesium, iron and sodium while calcium content decreased slightly. Among the elements, potassium gave the highest value in the two samples; this is in line with the findings of Ogunbusola et al. [7]. Several researchers have reported higher concentration of potassium in many Nigerian plant materials [16,17,18]. The potassium values for the two flours were higher than those reported for shells, shelled seeds and whole meal of *Citrullus lanatus* seed [4]. This high amount of potassium especially with defatted flour indicates its usefulness in the management of hypertension and diabetes due to their ability to reduce high blood pressure. Magnesium concentration in the

M. Sloanei flour stands second after potassium with 45.60 ± 0.01 mg/kg in full fat and 57.60 ± 0.02 mg/kg in defatted samples. Magnesium is an important requirement for thyroid and parathyroid production in the body. The decrease of Ca in defatted samples may be due to loss of Ca during removal of fats indicating Ca being present in oil complex. Calcium is required for neuromuscular activity and may retard elevated cholesterol in the blood stream. The sodium contents for the two samples were slightly lower than the value of Afam et al. [19] for germinated mung bean and higher than the range of values obtained by Ogoloma et al. [20]. Regarding iron contents, both samples have minor quantity, with the defatted sample presenting a slightly higher content. The improvement for most of the mineral elements after defatting could be an important industrial focus because mineral elements serve as important co factors for many metabolic and physiological processes in living systems.

3.1.2 Antinutrient composition of *M. sloanei* seed flours

The results exhibited reduction in concentration of phytic acid, phytin P and oxalate, however, an increase in concentration of glycosides and tannin was also observed. Reduction in phytic acid, phytin P and oxalate is an advantageous criterion as these are involved in reduced availability of minerals and other nutrients. Antinutrients are components that make valuable nutrients to be unavailable for proper utilization of plant materials but their presence has also been posited to be of advantage industrially and medicinally as they exhibits a number of protective functions in human existence [11]. Glycosides found in spices and drugs are helpful for patients suffering from heart problems, cancer and sickle cell anemia [2]. The low content of tannin in the samples is considered desirable because high amount is capable of lowering available proteins by antagonistic competition which can lead to protein deficiency in the body [20]. The increase in tannin content due to defatting could also be utilized in tanning of animal hides and skin to produce raw materials for shoes, bags and leather industries [2], inhibition of oxidation in wines and therapeutically to exert astringent effects on living tissues [21]. The decrease in phytic acid of 34.74% in defatted sample would be a great asset in food products to improve digestion and reduction in flatulence due to the reduction in certain sugar components of the seed during defatting.

3.1.3 Anti-oxidant composition *M. sloanei* seed flours

The analyses of antioxidant potential revealed an increase in DPPH, FRAP and phenol content (Table 3), whereas, a drastic decrease in flavonoid content was observed. The antimicrobial potential of the phenolic content of the flours especially the defatted sample could be utilized in skin disease treatment. The flavonoid contents of $8.26 \pm 0.00\%$ and $3.68 \pm 0.10\%$ respectively for full fat and defatted Ukpo seed flours were higher than 0.006% reported for *Mucuna flagellipe* seed [2] and this makes the full fat sample to be a very good and cheap source of flavonoid. Flavonoids are secondary metabolites usually referred to as unique pigments as well as natural radical scavengers that have memory and mood enhancing properties as well as the ability to protect

cells from oxidative damage [22]. The low content of flavonoid in the defatted sample would be desirable in the body because it will present a condition of lower level of interaction with certain nutrients and reduction in binding ability to the non-heme iron in the body. Flavonoid has been associated with preservative ability in food samples; hence the full fat sample with high flavonoid value is expected to have improved shelf life relative to the defatted sample (Table 3). The DPPH (%) and FRAP (mg/g) contents increased from 33.08 ± 0.06 to 35.13 ± 0.13 and 48.93 to 49.03 respectively from full fat to defatted samples. The two parameters have been linked with stability, therefore the slight increase observed for the two antioxidant properties in defatted sample could be utilized in food product development where stability is of importance.

Table 1. Mineral analysis of the full fat and defatted *M. sloanei* seed flours (mg/kg)

| Element | FFS | DFS |
|-----------|---------------------|---------------------|
| Sodium | 19.41 ± 0.01^a | 20.50 ± 0.01^b |
| Potassium | 279.33 ± 0.58^a | 324.00 ± 0.58^b |
| Calcium | 14.00 ± 0.01^a | 8.00 ± 0.01^b |
| Magnesium | 45.60 ± 0.01^a | 57.60 ± 0.00^b |
| Iron | 2.07 ± 0.01^a | 2.36 ± 0.01^b |

$n = 3$

Results are expressed as mean \pm standard deviation. Data having different superscripts across the row are significantly different ($p < 0.05$)

Table 2. Antinutrient compositions of the *M. sloanei* seed flours (mg/g)

| Parameter | FFS | DFS |
|--------------------|--------------------|--------------------|
| Glycosides (mg/kg) | 23.61 ± 0.01^a | 41.18 ± 0.01^b |
| Phytic acid | 20.15 ± 0.01^a | 13.16 ± 0.01^b |
| Phytin P | 5.68 ± 0.01^a | 3.70 ± 0.01^b |
| Oxalates | 7.11 ± 0.01^a | 0.47 ± 0.01^b |
| Iron | 0.37 ± 0.01^a | 0.47 ± 0.01^b |

$n = 3$

Results are expressed as mean \pm standard deviation. Data having different superscripts across the row are significantly different ($p < 0.05$)

Table 3. Antioxidant compositions of the *M. sloanei* seed flours

| Parameter | FFS | DFS |
|----------------|--------------------|--------------------|
| DPPH (%) | 33.08 ± 0.01^a | 35.13 ± 0.01^b |
| FRAP (mg/g) | 48.93 ± 0.01^a | 49.03 ± 0.01^a |
| Phenols (%) | 4.16 ± 0.01^a | 5.28 ± 0.01^b |
| Flavonoids (%) | 8.28 ± 0.01^a | 3.68 ± 0.01^b |

$n = 3$

Results are expressed as mean \pm standard deviation. Data having different superscripts across the row are significantly different ($p < 0.05$)

Table 4. Functional properties of full fat and defatted *M. sloanei* seed flours

| Parameter | FFS | DFS |
|---|---------------------------|---------------------------|
| Foaming capacity (%) | 6.00 ± 0.01 ^a | 30.30 ± 0.01 ^b |
| Foam stability (%) | 1.10 ± 0.01 ^a | 24.00 ± 0.01 ^b |
| Water absorption capacity (%) | 50.17 ± 0.29 ^a | 70.00 ± 0.01 ^b |
| Oil absorption capacity (%) | 19.51 ± 0.01 ^a | 21.75 ± 0.01 ^b |
| Emulsifying capacity (%) | 41.58 ± 0.01 ^a | 44.13 ± 0.01 ^b |
| Emulsion stability (%) | 39.61 ± 0.01 ^a | 34.32 ± 0.02 ^b |
| Least gelation concentration (g/cm ³) | 0.03 ± 0.01 ^a | 0.10 ± 0.01 ^b |
| Bulk density (g/cm ³) | 0.77 ± 0.01 ^a | 0.91 ± 0.01 ^b |

n = 3

Results are expressed as mean ± standard deviation. Data having different superscripts across the row are significantly different ($p < 0.05$)

3.1.4 Functional properties of *M. sloanei* seed flours

The functional properties of the full fat and defatted seed flours showed significant increase in all the determined parameters except in foaming capacity and emulsion stability. This observation was contrary to the finding of Ogunbusola et al. [7] who reported lower values of foaming stability, least gelation concentration and bulk density for defatted *Cucumeropsis mannii* seed flour. Adequate knowledge of the functional properties of the proteins is paramount to select plant food raw material with required properties in specific food formulations [23] and to determine acceptability for industrial and consumption purposes [24]. Water absorption capacity (WAC) is the ability of a product to associate with water under conditions where water is a limiting factor. The WAC contents of the two samples were lower than the values reported for most nuts and seeds [25], defatted conophor flour [26] and wheat and breadfruit flour samples [27]. The increase in WAC of the defatted sample could be explained in terms of the exposure and availability of polar amino acids group for interaction in the flour, this makes it to have more hydrophilic constituents such as polysaccharides than the full fat sample [28]. The increase in this property will make the defatted sample more useful in products where improved viscosity is of paramount importance.

Oil absorption capacity (OAC) is of paramount importance in food systems where oil imbibition is desired [29]. The increase in the OAC of the defatted flour could be as a result of the increased binding ability of the non-polar side of the flour with the hydrocarbon side chain of the oil or possibly due to the development of high β -sheet secondary structure [30]. Products made from the defatted sample are expected to be

more palatable and retain flavour relative to the full fat sample. Emulsifying capacity (EC) increased from 41.58% in full fat sample to 44.12% in defatted sample while the emulsion stability (ES) decreased from 39.61% full fat sample to 34.31% in defatted sample. The EC and ES for the full fat and defatted samples were higher than those reported for *Citrullus lanatus* seeds [31]. High EC of the defatted sample could be as a result of the exposure of the hydrophobic domain of the amino acid residue to the extractant due to the partial unfolding of protein [32] and possible reduction in the carbohydrate and fiber contents. The ES was the only parameter that was found to decrease after defatting, the reason for this could be attributed to the disruption of the protein protective cover or dissociation of the protein oligomeric structure during fat extraction thereby reducing the resistance of the defatted sample to deformation.

Foam capacity (FC) is the amount of interfacial area that can be created by protein while foam stability (FS) is the ability to stabilize against gravitational and mechanical stresses [28,33]. FC was found to increase from 6.00% in full fat sample to 30.30% in defatted sample. The increase in the value obtained for the defatted sample may be due to increase in the net charge of the protein molecule which weakens the hydrophobic interaction [30] and higher molecular flexibility [6]. This will enhance the ability of the defatted sample to spread more quickly to the air water interface thus encapsulating air particles [34] and would therefore be a good aerating agent in food products. The foam stability (FS) increased from 1.10% in full fat sample to 24.00% in defatted sample. The observed increase in the value of the defatted sample is explained in terms of the formation of cohesive viscoelastic film via intermolecular interactions [31] as well as lower

extent of unfolding and protein dissociation [35] and would therefore promote the use of the defatted sample in products that require stability of foam.

The least gelation concentration (LGC) and the bulk density (BD) of the two samples were considered low despite the little increase observed for the defatted sample. The increased in LGC from 0.03 g/cm³ in full fat sample to 0.10 g/cm³ in defatted sample is attributable to high concentration of protein in the defatted sample. Variation in gelling property has been associated with the ratio of different constituents such as proteins, lipids and carbohydrates in different legumes [36]. WAC is interrelated to gelation capacity, hence, the low WAC of the two samples may account for the deficient gelation formation capacity [10]. Defatted seed flour with slightly higher LGC is considered desirable because Olorode et al. [37] reported that high LGC will lead to reduction in viscosity, increase in nutrient density and low dietary bulk, which is highly favourable for a good weaning diet. The BD for the samples was higher than the range of values reported by Obiakor-Okeke and Anozie [8]. The averagely lower values for the two samples will enhance their caloric and nutrient intake per feed per child and infants will be able to consume enough to satisfy their energy and nutrient requirement. Defatted sample with slightly higher BD value will be more desirable in products that require greater ease of dispersibility [38].

4. CONCLUSION

The research work highlighted the importance of defatting process as a mean of improving nutritional quality of *M. Sloanei* seed flour. It could be concluded that the defatted *M. sloanei* seed flour have good nutritive mineral contents, reduced antinutritional factors and improved antioxidant characteristics relative to the full fat seed flour. The defatted seed flour can be used as a healthy food alternative especially in the tropics where there is poor protein nutrition. The research work also established the superior functional properties of the defatted seed flour and their potential industrial food applications especially where thickening, gelling and stability is required.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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