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Effects of Dehulling on Functional and Sensory Properties of Flours From Black Beans (*Phaseolus Vulgaris*)

—Properties of Black Beans Flours

Oluwole Akinjayeju*, Olayinka F. Ajayi

Department of Food Technology, Yaba College of Technology, Yaba-Lagos, Nigeria.
Email: olujayeju@yahoo.com

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ABSTRACT

The effects of dehulling on the physico-chemical and pasting of, as well as anti-nutritional factors in black bean (Phasoelus vulgaris) flours were investigated. Black bean seeds were dehulled both manually and mechanically and the flours obtained from the dehulled seeds were compared with flour milled from undehulled seeds. The flours obtained were evaluated for proximate composition, physical and pasting properties. Anti-nutritional factors in the flours were also determined. The flours were then used to prepare steamed bean cake ("*Moinmoin*") *which was evaluated for sensory parameters of appearance, taste, aroma, texture and overall acceptability. Dehulling produced significant effects* ($p < 0.05$) *on the proximate composition and physical properties. Both dehulling and method of dehulling had significant effect on most pasting properties. Method of dehulling however had no significant difference* ($p < 0.05$) *on the proximate composition and physical characteristics. Anti-nutritional factors were higher in flour from dehulled seeds compared to flours from undehulled seeds. There was no significant difference in all sensory parameters of* '*moinmoin*' ($p \geq 0.05$ *and* $p \geq 0.01$) *prepared from dehulled flours, but there was significant difference* ($p < 0.05$) *at both levels in most sensory parameters between samples from dehulled seeds and undehulled seeds except for aroma.*

Keywords: *Anti-nutritional Factors, Dehulling, Flours, Functional Properties,* "*Moinmoin*", *Black Bean, Sensory Properties*

1. Introduction

Legumes are the plants of the family *Fabaceace* or *Leguminosae* which serve as food for a large number of people of tropical origin and constitute a very important source of dietary protein in many West African countries, including Nigeria [1,2]). The widespread occurrence of malnutrition traced to low level of protein in the diets of those in many developing countries of the world had refocused on the importance of legumes as excellent but cheap source of legumes, most especially when consumed with cereal grains to which they act as extenders of proteins. In addition, it has been previously reported [3] that epidemiological studies had strongly supported the suggestion that high intakes of whole grain foods, including legumes, protect against the development of type II diabetes mellitus (T2DM). Common food legumes in Nigeria include cowpea, soybean, African locust bean and black bean and some lesser known ones including black beans [4].

Black bean (*Phaseolus vulgaris*) is one of the least exploited legumes in Nigeria despite its high level of protein and common minerals such as phosphorus and iron [5]. This low consumption of black bean has been attributed partly to its high content of anti-nutritional factors and hard-to-cook phenomenon which requires long time of cooking to make it safe and soft enough for consumption [6,7]. Black beans, like most common legumes, are consumed in different forms and used for the prepa- ration of various diets in Nigeria. One very form of consumption of legumes is a steamed paste gel of the legume ("Moinmoin"), which is prepared from the aqueous suspension of the milled legume after dehulling, either manually or mechanically [8,9].

Dehulling not only improves the cooking quality and reduces the antinutritional factors, but also improves protein quality, palatability, and digestibility of pulses [10]. While dehulling may be necessary in some legumes for preparation of "Moinmoin", it may not be important in some varieties of some legumes [11]. For small scale processing of legumes dehulling is usually achieved manually while mechanical Dehulling will be more ideal for commercial or large scale production especially for legumes with hard-to-cook phenomenon which makes manual dehulling rigorous, cumbersome and time consuming [12,13]. For proper utilization and acceptability of legume splits and flours, it is desirable to study the functional properties, physical and cooking properties, since they play important role in the physical behaviour of food or its ingredient during preparation and processing [14]. This study examined the effect of dehulling on some physico-chemical, functional and rheological properties of flours milled from dehulled and undehulled black beans, and evaluated the sensory properties of "Moinmoin" prepared from the flour samples.

2. Materials and Methods

2.1. Materials

The legume used in the study was black bean (*Phaseolus vulgaris*), which along with ingredients used for "moinmoin" preparation, were purchased from Mushin market on the outskirt of Lagos, Nigeria.

2.2. Preparation of Samples

Cleaned black bean seeds were divided into three portions and treated as follows. The first portion was mechanically dehulled by passing the seeds, which had been conditioned by the addition of 2% water (w/w), through an abrasive Double Grinding Mill (Addis Engineering Ltd., Lagos, Nigeria), to break the seeds into pieces and free the seed coat. The freed seed coat pieces were aspirated off using a locally fabricated grain aspirator followed by further cleaning to remove specs of seed coat. The second portion was manually dehulled by boiling in water for 30 mins followed by vigorous hand-rubbing to separate the seeds from the seed coat, as well as detaching the seed coat from individual seed, which was very cumbersome. The dehulled seeds were then dried in an air-drier (Uniscope Laboratory Oven, SM 9053, Surgifriend Medicals, England) at 55˚C for 8 hrs. The third portion was properly cleaned and treated as undehulled. Each of the three samples was milled separately in a locally fabricated attrition mill followed by sieving in a test sieve shaker (Endecotts Octagon 200, England.), and the fraction which passed through 425 µm screen was collected and used for further study.

2.3. Proximate Analysis

The proximate composition of each flour sample in terms of moisture, ash, fat and crude fibre was determined by standard methods [15]. Carbohydrate was determined by difference.

2.4. Functional Properties Determination

Functional characteristics of the flour samples were determined for water absorption, swelling, solubility and loose bulk density using the methods of [16].

2.5. Pasting Properties

The pasting properties of the flour samples were determined using the Rapid Visco Analyzer (RVA) [17]. Parameters obtained from the evaluation were peak, trough and cooled-paste viscosities, which were used to determine the consistency, setback and breakdown as well as the pasting temperature and time.

2.6. Determination of Anti-nutritional Factors

Phytate, polyphenol and trypsin inhibitor index of each flour sample were determined by standard methods [15].

2.7. Preparation of Moinmoin and Sensory Evaluation

The flour samples were used to prepare "Moinmoin" using the recipes of [18]. The "Moinmoin" samples were evaluated for colour, aroma, taste, texture and general acceptability. A 15-member untrained taste panel, selected from among staff and students from department of Food Technology, Yaba College of Technology, Lagos, Nigeria, who are familiar with the quality parameters of "moinmoin" was used to conduct a scoring test on a grading scale ranging between 1 for "like extremely" and 9 for "dislike extremely", with "neither like nor dislike" in between. The responses of panelists were converted to numerical values and subjected to analysis of variance [19].

3. Results and Discussion

3.1. Proximate Composition

The proximate compositions of the flour samples are shown in **Table 1**. Values obtained in this study for the proximate composition of the flours are in agreement with values previously reported [20,21] etc. Dehulling produced significant effects on the proximate compositions of the flours except for moisture. Undehulled samples recorded higher values for most parameters except carbohydrate for which undehulled sample had lower value compared to dehulled samples.

Method of dehulling had no appreciable influence on the proximate compositions of the flours since flours milled from both manually dehulled and mechanically dehulled seeds had almost similar proximate composi-

Table 1. Effects of dehulling on the proximate compositions of black bean flours (%).

Parameters*/Samples	Moisture	Protein	Fat	Ash	Fibre	Carbohydrates
Mechanically dehulled	$10.39^{a} \pm 0.45$	$19.93^{b} \pm 0.83$	$2.93^{d} \pm 0.12$	$3.63^{e} \pm 0.36$	$4.18^{h} \pm 0.42$	$58.94^{i} \pm 1.72$
Manually dehulled	$10.34^{a} \pm 0.64$	$20.47^{b} \pm 0.58$	$3.08^{d} \pm 0.11$	$3.68^{e} \pm 0.21$	$4.31^{h} \pm 0.58$	$58.12^{i} \pm 0.98$
Undehulled	$10.17^{a} \pm 0.30$	$23.50^{c} \pm 0.31$	$4.18^{f} \pm 0.14$	$5.04^{g} \pm 0.07$	$5.28^{j} \pm 0.59$	$51.83^{l} \pm 1.11$

*****: Expressed as dry-weight except for moisture; Means with the same letters along the same column are not significantly different at $p < 0.05$.

tions. These results are in agreement with the observations of [11,13] who worked on cowpea. The slight increase in the ash and crude fibre contents of manually dehulled sample compared to that mechanically dehulled is most likely due to the near total removal of the seed coat in mechanically dehulled sample, indicating more effective dehulling, unlike for manually dehulled sample in which the seed coat, which is responsible for the ash and crude fibre, may not have been completely removed [5,22]. This may also be responsible for the slightly lower protein content in flour milled from mechanically-dehulled seeds compared with that from manually dehulled seeds.

Moreover, scutellum in the seed, which has been reported to contain little amount of protein in grains like cereals and legumes, may have been removed in mechanically-dehulled sample than in its manually-dehulled counterpart. The relatively higher lower value of carbohydrate in undehulled flour compared to dehulled samples was due to the higher protein, ash and crude fibre contents of undehulled sample, unlike for dehulled samples. There is an increase in the protein content of flour milled from undehulled seeds, a result which is in agreement with the observation of [13], who worked on cowpea, that protein contents of flours from dehulled samples were slightly lower than for flours from undehulled seeds. However, in this study, the increase in protein in undehulled sample is higher than the results obtained for cowpea, which is most probably due to higher level of protein in the seed coat of black bean compared to that in cowpea. These results are also in agreement with the observations of [20,21] both of whom worked with black beans amongst other legumes.

The reduction in the protein contents in dehulled samples is most likely due to the removal of the scutellum and aleurone layer in the seed both of which had been reported to contain up to 20% of the protein in grains. This result however contradicts the observation of [13], who reported that for cowpea, the protein contents of flour from dehulled seeds were only slightly higher than for flour milled from undehulled seeds. This could not be attributed to any obvious reason. This is most probably due to higher protein content in the seed coat of cowpea compared to the cotyledons as opposed to that of black bean.

3.2. Functional Characteristics

The functional characteristics of the samples are summarized in **Table 2**. These results shown that there was no significant difference in the means of parameters measured for dehulled samples, unlike for undehulled samples which showed significant difference for all parameters when compare with undehulled samples. These results showed that dehulling method has no effect on the functional properties of the flours. Similar observations were made by previous researchers [11,13] in studies on dehulling characteristics of cowpea. The reduction in the water absorption and swelling of flour from undehulled is most probably due to the reduction of starch and higher fibre content in this sample compared to dehulled samples. The starch component of plant materials is responsible for water absorption and subsequent swelling while presence of fibre will lower the occurrence of these properties.

The high bulk density value for flour milled from undehulled sample is due to the presence of fibres which contributes to bulkiness in the flour sample as opposed to those from dehulled seeds. The high bulk density of undehulled sample is in agreement with the observation of [23,24] that bulk density was highest in control (undehulled) legume flours and that dehulling can be used to improve the functional properties of legume meals. The low water absorption and swelling in dehulled sample will have certain effect on the texture of the food prepared from such flours.

3.3. Pasting Properties

The pasting properties of the flour samples are as presented in **Table 3**. Dehulling and methods of dehulling produced significant effects on most pasting characteris-

Table 2. Effects of dehulling on the functional properties of black bean flours (%).

Parameters/Samples	Mechanically dehulled	Manually dehulled	Undehulled
Water absorption	$75.50^{b} + 1.36$	$75.36^{b} + 1.87$	$67.88^{c} + 2.01$
Swelling	$9.66^{d} + 0.97$	$9.55^{d} + 0.76$	$7.45^{e} + 0.21$
Solubility	$8.55^{f} + 0.75$	$8.77^{f} + 1.11$	$6.25^{g} + 0.91$
Bulk density (Kg/m^{-3})	$145^{i} + 1.23$	$146^{i} + 1.98$	$153^{j} + 1.53$

Means with the same letters along the same row are not significantly different at $p < 0.05$.

tics measured except pasting temperature and peak time. While mechanically dehulled sample had the highest pasting characteristic values, undehulled sample recorded the least values. Pasting temperature provides an indication of the minimum temperature required to cook the flour [25]. All the three samples had almost similar pasting temperature values which are not significantly different. This could be attributed to similar particle size of the flours. These values are however slightly lower that the values previously reported [25,26] on studies of black bean amongst other common legumes. This could be due to the methods these authors used to produce the flours as well as varietal and agronomic differences in the legumes studied. These results are however in agreement with the observations of [14] who reported no appreciable differences in the gelatinization temperatures of cowpea flours from dehulled and undehulled seeds.

The higher viscosities recorded for mechanically dehulled sample compared to its manually dehulled counterpart could be attributed mostly to the treatments given to manually dehulled samples especially boiling and drying prior to milling, unlike the mechanically dehulled sampled which did not undergo such treatments before dehulling and milling. The low viscosity values for sample milled from undehulled seeds could be attributed to the presence of fibres from the seed coat, and relatively lower carbohydrate content, which also affected the water absorption of this sample as this study indicates (**Table 2**).

Stability and consistency of flours have important influence on the mixing tolerances of gels and pastes [27]. These parameters are expected to have significant effects during the preparation of "moinmoin". Sample milled from mechanically dehulled seeds had the highest values for these parameters, an indication of likely more resistance to shear and mixing. Low setback value gives an indication of low tendency to retrograde [24]. While sample from mechanically dehulled seed recorded the highest value (94 RVU), sample from undehulled seeds had the least (34 RVU), an indication that the diets prepared from the dehulled flour will produce less retrogradation, which will be beneficial since retrogradation will produce adverse effects on the properties of food products, especially the sensory properties [28,29]. Values for stability and consistency for manually dehulled sample fall in between values for mechanically dehulled and undehulled samples.

3.4. Anti-nutritional Factors

The phytate, polyphenol and trypsin inhibitor activity of the flour samples are presented in **Table 4**. These results show levels of polyphenol and trypsin inhibitor activity in black bean compared to phytate content. These results confirm the observations in previous studies that black bean contains considerable amounts of anti-nutritional factors namely protease, protein and amylase inhibitors, phytic acid and polyphenolic compounds amongst others [7,25,26,30]. Method of dehulling produced no significant effect on the anti-nutritional parameters measured since values obtained for parameters measured are similar for both mechanically and manually dehulled samples, unlike for undehulled sample.

Anti-nutritional values for this sample was higher than for dehulled samples. This is an indication that a large

Table 3. Effects of dehulling on the pasting characteristics of black bean flours (RVU).

Parameters/Samples	Mechanically dehulled	Manually dehulled	Undehulled
Peak viscosity (a)	$320^a \pm 2.01$	$279^b \pm 1.76$	$247^c \pm 2.36$
Holding viscosity (b)	$258^d \pm 1.96$	$235^e \pm 1.87$	$214^f \pm 1.42$
Cooled-paste viscosity (c)	$414^c \pm 2.45$	$356^d \pm 2.01$	$281^e \pm 1.87$
Breakdown/Stability (a-b)	$62^g \pm 1.11$	$44^h \pm 0.97$	$33^i \pm 1.23$
Setback(c-a)	$94^e \pm 1.08$	$77^f \pm 2.01$	$34^g \pm 1.86$
Consistency(c-b)	$156^f \pm 1.96$	$121^g \pm 1.25$	$67^h \pm 1.62$
Pasting temp (˚C)	$80.31^a \pm 1.81$	$82.25^a \pm 1.98$	$81.63^a \pm 1.11$
Peak time (Mins)	$5.20^b \pm 0.17$	$5.33^b \pm 0.28$	$5.67^b \pm 0.46$

Means with the same letters along the same row are not significantly different at $p < 0.05$.

Table 4. Effects of dehulling on the pasting characteristics of black bean flours (RVU).

Parameters/Samples	Mechanically dehulled	Manually dehulled	Undehulled
Trypsin Inhibitor Activity	$2.55^a \pm 0.07$	$2.48^a \pm 0.19$	$3.55^b \pm 0.28$
Phytate	$44.88^d \pm 1.97$	$45.22^d \pm 2.11$	$88.65^e \pm 1.67$
Polyphenol	$1.33^c \pm 0.08$	$1.28^c \pm 0.15$	$1.66^c \pm 0.35$

Means with the same letters along the same row are not significantly different at $p < 0.05$.

percentage of the anti-nutritional factors are contained in the seed coat, which has been removed in samples from dehulled samples. This means that foods pre- pared from dehulled samples will be more detoxified compared to those from undehulled samples, which agrees with the previous studies that dehulling reduces the antinutritional factors, in addition to improving the cooking and protein quality, palatability and digestibility of pulses [10].

3.5. Sensory Parameters

The mean scores and calculated variance ratios of the sensory parameters of "moinmoin" prepared from the flour samples are summarized in **Table 5**. The mean scores obtained show that "moinmoin" prepared from dehulled seeds were more acceptable to panelists in almost all parameters evaluated as compared to that prepared from undehulled seeds which recorded higher mean scores, an indication of reduced acceptability (9 for dislike extremely). There was no significant difference among samples prepared from mechanically and manually dehulled seeds for all parameters evaluated. However, there was significant difference between dehulled samples and undehulled sample for all parameters except aroma. This is however not the case for taste which is expected to show similar trend with aroma. This could not be attributed to any obvious reason.

The low acceptability rating of the moinmoin from undehulled sample could be attributed to the presence of the seed coat which most probably produced adverse effects on most sensory parameters. The low acceptability taste of the "moinmoin" prepared from undehulled bean is most likely as a result of the characteristic beany flavor in most legumes which is prevalent mostly in the seed coat and considered offensive to most consumers [5]. Low acceptability ratings for colour of "moinmoin" prepared from undehulled brown cowpea were earlier reported [11,13], observations which are in agreement with the present study.

Table 5. Mean scores and calculated variance ratios of sensory parameters of "Moinmoin" prepared from dehulled and undehulled black bean flours.

Parameters/Samples	Mechanically dehulled	Manually dehulled	Undehulled	$F_{cal.}$
Taste	$2.40^a + 0.29$	$2.61^a + 0.23$	$4.07^b + 0.32$	34.09
Appearance	$2.53^c + 0.11$	$2.73^c + 0.22$	$4.53^d + 0.16$	47.73
Aroma	$2.33^d + 0.27$	$2.38^d + 0.16$	$2.78^d + 0.23$	2.81
Texture	$2.23^e + 0.18$	$2.01^e + 0.22$	$4.21^f + 0.20$	21.21
Overall acceptability	$1.73^f + 0.17$	$1.93^f + 0.28$	$4.33^g + 0.27$	58.49

Means with the same letters along the same row are not significantly different at $p < 0.05$; 1 = liked extremely and 9 = disliked extremely; F_{tab} (From Statistical Tables) $F_{(0.01)} = 5.45$; $F_{(0.05)} = 3.34$.

4. Conclusions

This study showed that removal of seed coat of black bean prior to milling into flour had appreciable influence on most functional and pasting properties of the milled flours. It also showed that dehulling resulted in significant reduction in the anti-nutritional factors of the flours, and produced appreciable effects on the sensory properties of "moinmoin" prepared from the flour milled from dehulled seeds. However, results showed that the method of dehulling employed produced very little effect on the properties of the flours as well as on the sensory parameters of moinmoin prepared from the milled flours. This will be very beneficial during the dehulling of the legume, especially on a commercial scale where mechanical dehulling could be employed to obtain high dehulling rates without any adverse consequences on the properties of the milled flours. As noted earlier, manual dehulling of black bean could be very cumbersome and time consuming, due to the presence of hard-to-cook phenomenon which is common to most legumes. This means that for commercial production of flour from black beans, mechanical dehulling would be preferred to manual dehulling without any fear of possible adverse effects on the properties of the flour and the sensory parameters of steamed bean cake prepared from such flour.

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