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Investigation into the Functional and Sensory Properties of Two Varieties of Local Black Beans (Phaseolus Vulgaris) Flour

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Abstract: *Investigation was carried out on functional and sensory properties of two varieties of local black beans (Black and Brown) flour. The aim of this research was to generate relevant scientific data on the functional and sensory properties of two varieties of local black beans consumed in Nigeria. The result of the functional properties revealed a Bulk Density of 0.412g/cm^3 for brown bean and 0.418g/cm^3 for black bean. The Water Absorption Capacity, Oil Absorption Capacity, Swelling Index, Gelatinization Temperature, Wettability, Foam Capacity, Foam Stability, Emulsion Capacity, Emulsion Stability and pH of the two samples were: Brown bean; 2.56g/g, 2.17g/g, 1.84ml, 83.80^{o}C, 49.50sec, 18.91%, 12.18%, 24.78%, 19.31% and 6.45 respectively, Black bean; 2.76g/g, 1.94g/g, 1.80ml, 84.0^{o}C, 51.00sec, 17.47%, 12.31%, 22.57%s, 19.48% and 6.49 respectively. The result of the Sensory evaluation carried out by Twenty (20) panelists on the flour samples for overall acceptability revealed that both flour samples had negligible difference in the score for sensory properties. The score for appearance, flavor, and taste were higher for brown bean flour than black bean flour. The findings reveal that both black and brown varieties of local beans are good bakery material and the functionalities make them a good food supplement.*

Keywords *- Black bean, brown bean, functional properties, protein, sensory properties*

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I. Introduction

Legumes are the edible seeds of leguminous plants of the family *Fabaceace* or *Leguminosae*. Those used as food are divided into two groups, namely: the pulse and oil seed [1]. Leguminous plants play an important role as sources of protein and energy [2], thereby serving as food for human beings and feed crops for farm animals [3]. Legumes are also gaining relevance for their health benefits [4]. They constitute a substantial percentage of the total intake in Nigeria [2], being the key components of diets and even the major staple crop in other regions of the world [5]. 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 protein, most especially when consumed with cereal grains to which they act as extenders of proteins [6].

The prices of the conventional protein sources are too high for rural farmers to bear. There is dire need to look for a source that is not only cheap but very available. Herbaceous leguminous plant such as local vegetable black bean and its two varieties are abundant in sub-Saharan region of Africa, most especially Nigeria were these are used as food or feed [7]. This is however due solely to the fact that they are also a good source of complex carbohydrates and dietary fiber. They contain significant amounts of vitamins and minerals in addition to their high percentage protein content which make them potential protein sources for food industries applications. This potential usefulness will depend on their functional properties [8]. The physiochemical properties of food nutrients which affect their behavior during processing, preparation, storage and consumption, in food system are as a result of their respective functional and sensory properties [7].

Further studies on the different bean cultivars could be the basis for the development of new products, since the industry needs this information in order to select the best variety for use in industrial processing. The purpose of this study was to investigate the properties of different cultivars of black beans in relation to their functional and sensory characteristics, aiming to generate relevant data that would improve awareness on their potential for human and animal food formulations.

II. Materials and Methods

2.1 MATERIALS

The raw materials used for this study were black colored beans (Akidi) and brown colored beans (Akidi). All the raw materials were purchased from Nkwo Achara market, Uturu, Isiukwuato Local Government Area, Abia State, Nigeria. They were packed in polyethylene bags after purchase and stored at room temperature until needed.

2.1.1 Apparatus

The apparatus and chemicals used for the production and analysis were obtained from Reliable Research Laboratory Services, Ehinmiri Umuahia, Abia State, Nigeria.

2.1.2 Sample Preparation

Okezie and Bello in [9] was employed. The bean varieties were sorted, cleaned to remove extraneous materials, dirt and infected seeds. The seeds were milled into flour after drying preceded dehulling which was done by soaking in water for 6hours which helped to loosen the hulls easily from the seed. The flour obtained was sieved into fine flour and stored in an air tight container until needed for use.

2.2 FUNCTIONAL PROPERTIES OF FLOUR SAMPLES

The Black bean flour samples functional properties were investigated according to the method specified in [10] [9] [11] [12] [13] [14].

2.2.1 Bulk Density

The method of Okaka and Potter was used [10]. A measure of 50grams flour sample was put into a calibrated measuring cylinder. The bottom of the cylinder was tapped repeatedly on a pad placed on a laboratory bench. Tapping was done until there was no further reduction in the volume occupied by the sample. The bulk density was determined as the ratio of the weight of the sample to its volume calculated as shown below;

$$Bulk\ Density = \frac{W}{V}$$

Where W = weight of sample in gram
V = volume of sample in cubic centimeter.

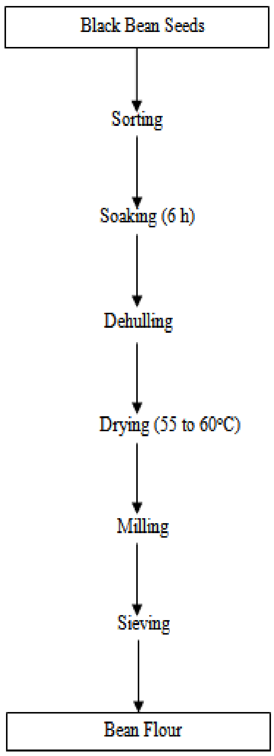

Fig. 1 Flow diagram for the production of black beans flour
Source: [26].

2.2.2 Water Absorption Capacity

The method of Lin et al. [11] modified by Okaka and Potter [12] used. One (1) gram of the sample was weighed and put into a test tube. 10ml of distilled water was added to the sample and mixed well. The mixture was allowed to stand for 30minutes at room temperature. The mixture was centrifuged at 3500rpm for 30 minutes. The supernatant was decanted and measured. Therefore;

$$WAC = V_1 - V_2$$

Where WAC = water absorption capacity
V_1 = Initial volume of distilled water
V_2 = Final volume of distilled water

2.2.3 Oil Absorption Capacity

This was determined in the same way as water absorption capacity. However, a refined vegetable oil was used in place of water and the time allowed for absorption was longer (1hour at room temperature as against 30minutes for water). The oil absorption capacity was determined by difference, as the volume of oil absorbed and held by 1gram of the samples as shown below; Oil absorption capacity = (initial volume of oil) – (final volume of oil).

2.2.4 Foaming Capacity and Foaming Stability

The method of Narranyana and Rao [13] was used to determine the foam capacity and foam stability. One gram of sample was mixed with 10ml of distilled water, blended and centrifuged at 1600rpm for 5minutes. After the resulting mixture was poured into a 250ml measuring cylinder, the volume of foam was recorded after 30 seconds. The foaming capacity was expressed as a percentage of foam produced after whipping. It is calculated as;

$$Foaming\ Capacity = \frac{V_a - V_b}{V_b} \times \frac{100}{1}$$

Where; V_a = Volume after whipping
V_b = Volume before whipping
The volume of foam was recorded one hour after whipping to determine foam stability as per percent of initial foam volume.

2.2.5 Emulsion Capacity

Method of Okezie and Bello [9] was used. Two (2) grams flour sample was blended with 25 ml distilled water at 10^{o}C temperature for 30seconds in a warring blender at 1600rpm. Complete dispersion of 25ml vegetable oil was added and blended for another 30seconds. The mixture was later transferred into a centrifuge tube and centrifuged at 1600rpm for 5minutes. The emulsion capacity was expressed as the amount of oil emulsified and held per gram of the sample. It is shown below;

$$Emulsion\ Capacity = \frac{Emulsion\ height}{Water\ height} \times \frac{100}{1}$$

2.2.6 Emulsion Stability

The method of Yatsumatsu et al [14] and Okezie and Bello [9] were used.. Two (2) grams of flour sample was weighed into a calibrated centrifuge tube. 10ml distilled water and 10ml refined vegetable oil was added to it. It was later centrifuged at 200rpm for 5minutes. After then, the emulsion was heated at 80^{o}C for 30minutes in hot water bath. It was later cooled under running water for 15minutes and centrifuged at 200rpm for 15minutes.
The emulsion stability expressed as percentage was calculated as the ratio of the height of emulsified layer to the total height of the mixture. It is shown below;

$$Emulsion\ stability = \frac{Height\ of\ emulsified\ layer}{Height\ of\ whole\ layer} \times \frac{100}{1}$$

2.2.7 Gelatinization Temperature

Five (5) grams of sample was weighed into a beaker with 20ml of water and heated until gelling point. The temperature was measured 30seconds after gels using a thermometer.

2.2.8 Swelling Index

The calculation for the Swelling index was done using the method of Ukpabi and Ndinele [15]. One (1) gram of the processed sample was weighed and dispersed into a test tube, leveled and the height noted. Distilled water (10ml) was added and allowed to stand for 1hour. The height was then recorded and the swelling index calculated as the ratio of the height to the initial height

$$Swelling\ Index = \frac{H_2}{H_1}$$

Where H_2 = Final height
H_1 = Initial height

2.2.9 Wettability

This was determined as the time (in seconds) taken by a unit weight (1g) of the flour sample to get completely wet on the sample of water under laboratory conditions. The method used was described by Okezie and Bello [9]. About 500ml of water was measured into a clean glass beaker (600ml capacity). With the aid of retort stand, it was arranged such that a clean test tube was clamped in an inverted position over the water in the beaker. The clamped position was adjusted such that the distance from the mouth of the test tube to the surface of water in the beaker was exactly 10cm. Both the water in the beaker and the clamped position were marked with masking tape. Subsequently, one gram of the sample was weighed into the marked test tube and its mouth covered with a thumb. It was carefully inverted over the water and clamped with the retort stand at the marked spot without removing the thumb. With the stop water set to read, the thumb was removed and the sample allowed to fall into the water surface as the stop watch was put simultaneously. The flour samples were observed and the stop watch stopped as the last few sample got wet.

2.2.9 pH

The pH was measured directly using a pH meter. Ten (10) grams of the sample was weighed and dissolved in a beaker containing 25ml of distilled water to form slurry. It was allowed to stand for 10minutes with constant stirring. The pH was then determined with a pH meter (R1-02895 HANNA/Italy).

2.3 SENSORY EVALUATION

The sensory evaluation of Black bean samples (Akidi) was conducted using twenty (20) panelists. A preference analysis using a nine (9) point Hedonic Scale with 1=like extremely, 5=neither like nor dislike and 9=dislike extremely was adopted according to Iwe (2010). Appearance, flavor, texture, taste and overall acceptability were evaluated.

Table 1: Functional properties of local bean flour

PARAMETER	BLACK	BROWN
BD (g/cm^3)	0.418 ± 0.01	0.412 ± 0.01
WAC (g/g)	2.76 ± 0.00	2.56 ± 0.20
OAC (g/g)	1.94 ± 0.00	2.17 ± 0.01
SI (ml)	1.80 ± 0.01	1.84 ± 0.01
GT(^oC)	84.00 ± 0.00	83.80 ± 0.00
WETT (Sec)	51.00 ± 0.00	49.50 ± 0.00
FC (%)	17.47 ± 0.01	18.91 ± 0.01
FS (%)	12.31 ± 0.01	12.18 ± 0.01
EC (%)	22.57 ± 0.06	24.78 ± 0.00
ES (%)	19.48 ± 0.01	19.31 ± 0.01
pH	6.49 ± 0.00	6.45 ± 0.00

All values are expressed in dry weight bases as means $\pm$ Standard Deviation of three determinations. BD, Bulk density; WAC, Water absorption capacity; OAC, Oil absorption capacity; SI, Swelling index; GT, Gelatinization temperature; WETT, Wettability; FC, Foam capacity; FS, Foam stability; EC, Emulsion capacity; ES, Emulsion stability; pH, Potential Hydrogen.

Table 2: Sensory properties of local bean flour

ATTRIBUTE	BLACK	BROWN
Appearance	4.35 ± 0.63	4.45 ± 0.44
Flavour	3.40 ± 0.03	3.50 ± 0.37
Texture	3.70 ± 030	3.70 ± 0.35
Taste	2.80 ± 0.56	3.70 ± 0.35
Overall acceptability	2.90 ± 0.32	3.05 ± 0.54

All values are means $\pm$ Standard Deviation of twenty (20) panelists. 1 = liked extremely and 9 = disliked extremely.

III. Results and Discussion

The results of the functional properties of the two varieties of Nigerian local beans (Black and Brown) flour are shown in Table 1. The functional properties of food materials are very important for the suitability of diet, particularly for the growing children [16].

The bulk density (BD) is a reflection of the load the samples can carry if allowed to rest directly on one another [7]. The black local bean flour showed a little higher bulk density (0.418 g/cm^3) than the brown bean flour (0.412 g/cm^3) as depicted in Table 1. This gives indication that it is heavier than brown bean flour and would occupy lesser space per unit weight and hence packaging cost would also be lesser when compared with brown cultivar. The black cultivar will also be desirable for greater ease of dispersibility of flour. The bulk densities observed in this study were lower than that observed for cowpea varieties (0.71g/cm^3) and Pigeon pea (0.68g/cm3) investigated by Butt and Batool [17]. It was also lower than the values (0.69g/cm^3; 0.80g/cm^3; 0.79g/cm^3) for three local varieties in Ghana [18].). The low bulk densities of the flours suggest that they would be suitable for the production of complementary foods, since, low bulk density would be an advantage in the formulation of complementary foods [19].

Water Absorption Capacity (WAC) of the black bean flour (2.76g/g) was higher than that for brown bean flour (2.56g/g). The lower water absorption capacity of brown bean flour may be attributed to lower protein content comparative to black bean flour [20]. The values for both samples were higher than the 1.60g/g and 1.94 g/g reported by Chinma et al. [21] for some cowpea varieties in Nigeria. It was also higher that the range of 2.05g/g -2.52g/g reported by Onuegbu et al. [22]. According to Butt and Batool [17], protein has both hydrophilic and hydrophobic properties, and so can interact with water in foods. The water absorption capacity is an indication that a particular sample should be useful in food system for bakery product [23].

Oil absorption capacity was 1.4g/g for black bean flour and 2.1g/g for brown bean flour. Appiah et al. [18] have reported oil absorption capacities for the three cowpea cultivars in the range between 1.95 and 2.31 g/g. The values observed in Table 1 were similar to the range observed by [18]. These results show that both cultivars may have similar lipid or hydrophobic groups present. Since the oil binding capacity of food protein depends upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity [24]. The oil absorption capacity helps in facilitating appropriate flavor and mouth feel, resultantly making the flours suitable in food preparations [25].

Swelling power is the ability to increase in volume when foamed [26]. The Swelling index did not show much difference between the two varieties of bean flour. The value for the swelling index was 1.80ml for black bean flour and 1.84ml for the brown bean flour. The swelling powers of the flour varieties studied were lower than the values (2.65ml, 2.66ml and 2.68ml) for three local varieties of cowpea from Ghana [18]. It was also lower than the values (7.45ml, 9.55ml, and 9.66ml) for three varieties of black bean flour reported by Oluwole and Olayinka [6]. The lower swelling index of the black and brown varieties of the bean flour investigated could be due to presence of fibre content. The effect of their swelling index will be reflected on the texture of food prepared from such flours.

The temperature at which gelatinization of starch takes place is known as the gelatinization temperature [27]. The gelatinization temperature observed for black bean flour was (84^{o}C) and higher than the temperature value of gelatinization for brown bean flour (83.8^{o}C), although both samples had high gelatinization temperatures. Gelatinization temperature is influenced by the amount of loose starch granules available in the sample. It could be explained that brown bean has higher loose starch granules since this investigation shows that it has lower gelatinization temperature. The gelatinization temperatures found in this study were higher than the values for different varieties of cereals [28].

Wettability shows how proficient a flour sample will be distributed. Therefore, the flour samples that will disperse fastest in water are the ones with the lowest wettability [29]. A higher wettability value was recorded for the black bean flour in Table 1 when compared to the brown bean flour. The wettability of the flours was found with wettability time of 51.60sec for black bean and 49.50sec for brown bean flour. Higher values of wettability indicate lower reconstitution properties [29]; therefore, the wettability results implied that, black bean flour required much longer time than the brown bean flour sample before it became completely wet or reconstituted.

Table 1 shows the foaming capacity of the two varieties of local bean flour with the brown variety having a higher foam capacity value (18.91%) when compared to the black variety (17.47%). The foam capacities of both samples were comparatively lower than the 40% reported for wheat flour [30]. However, the values for the flour samples investigated in this study were comparatively higher than 11.30% and 9% reported for pear millet and quinoa flours respectively [31]. This high value could be due to higher protein content. Protein in the dispersion may cause a lowering of the surface tension at the water-air interface, as protein forms a continuous cohesive film around the air bubbles in the foam [32]. The high values of both flour samples show that they would be useful as aerating agent in food systems such as Akara and moi-moi which require stable high foam volumes when whipped [33].

The foam stability refers to the ability of protein to stabilize against the gravitational and mechanical stresses [34]. The observed foam stability value for black bean was 12.31% while the value for brown bean flour sample was 12.18%. An inverse relationship was seen in Table 1 between Foam capacity and foam stability. Flours with high foaming ability could form large air bubbles surrounded by thinner less flexible protein film. These air bubbles might be easier to collapse and consequently lower the foam stability [35]. Foam stability also depends on molecular size which is directly correlated to interface properties [36]. The values observed in this study were comparatively higher than the value of 1.94%, 4.0%, and 9.2% reported for different flour samples by Suresh et al. [37].

Table 1 shows the emulsification properties of the two varieties of the local bean flour. The emulsion capacity and emulsion stability values of the local bean flour samples were found higher than Wheat flour reported by Mepba et al. [38]. The brown bean had values of 24.78% and 19.31% for emulsion capacity and stability respectively while the black bean had 22.5% and 19.48% for emulsion capacity and stability respectively. The discrepancy in emulsion capacity of both flours could be attributed to differences in their globular protein contents. Flour with good emulsion capacities will be useful in the preparation of comminuted meat products and analogs [39]. Lin et al. [11] presented a report on the emulsion capacity of wheat flour, Soy flour, Sunflower flour and protein concentrates and isolates from Soy and sunflower flour which were in the range of 10.1%−25.6% with the exception of sunflower flour (95.1%). The formation and stabilization of emulsions are important for many applications in food products like cake, coffee whiteners and frozen desserts [40].

Black bean had a high pH value than the brown bean. This implies that the brown bean has more acidic content than the black bean [41].

3.1 SENSORY EVALUATION

Table 2 shows that black bean had lower score 4.35 compared to brown bean which had 4.45 for appearance. The values for flavor were 3.40 and 3.50 for black bean respectively. This implies that brown beans add flavor to food or bakery products manufactured with brown bean flour.
Black bean had 3.80 for taste. This is high compared to brown beans (3.70). Both flour samples had (3.70) score for texture, while the overall acceptability score for black beans flour and brown beans flour were 3.90 and 3.05. The sensory evaluation indicated a higher preference for brown beans flour when compared to black beans flour.

IV. Conclusion

This study showed that black and brown bean had low bulk density, high oil absorption capacity and high foam capacity. This is an indication that the two flour samples will make a good bakery material. However, the result of the sensory evaluation showed a better preference for the brown bean flour than the black. This means that food or bakery products from the brown bean will be generally more acceptable to consumers when utilized for commercial purposes. Further study on the proximate, nutritional and anti-nutritional composition should be carried out to increase knowledge of the flour samples.

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