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Physicochemical and functional properties of flour from dehulled white African Yam Bean (*Sphenostylis sternocarpa*) grown in Anambra state, Nigeria

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ABSTRACT

The physical, proximate and functional properties of white variety of African Yam Bean grown in Anambra state, Nigeria were studied. The average seed weight was obtained as 0.13±0.01g, while the size was about 0.70 X 0.48 X 0.38mm. Result of the proximate analysis of the dehulled flour of African Yam Bean seeds showed the percentage of moisture, protein, fat, crude fiber, ash and carbohydrate contents to be 8.50%, 22.48%, 1.50%, 2.44%, 3.43% and 61.65% in that order. Functional properties were also analyzed and the results for the water and oil absorption capacities were 1.18ml/g and 0.08ml/g respectively. Also the swelling index, wettability, bulk density, emulsion capacity, gelling point and boiling point were 2.25ml, 44.6 seconds, 0.89ml/g, 2.3ml/g, 52^{0}C and 64^{o}C respectively. Overall acceptability of the flour was quite high, and ultimately, result showed that African Yam Bean has properties that could be of use in food formulation systems. © 2014 Trade Science Inc. - INDIA

KEYWORDS

Physicochemical properties;
Functional properties;
Odudu;
African Yam Bean;
White African Yam Bean flour.

INTRODUCTION

African Yam Bean (*Sphenostylis sternocarpa*) belongs to the genus *sphenostylis*, the subtribe *phaseolinae*, the tribe *Phaseoleae* and the family *Papilionanceae*. It is a typical African plant grown in most parts of the hot and humid tropical regions at middle and low altitudes and more especially in Southern Nigeria[15].

The leguminous plant (AYB) is treated mostly as an animal crop and used both for its seeds and tubes. The stems may be climbing and ranges from 1-3m in length. The dry seeds are harvested to meet family demands, except where farmers intend to sell the seeds. This is made possible by the fact that dry pods do not shatter easily. The last harvest may be done in December. Intermeshed pods are often tied into bundles and hung or stashed above the fireplace in the kitchen where storage smoke from the firewood for cooking repels storage pests thereby facilitating long term storage[11]. African Yam Bean is commonly called *Odudu* or *Azima* in several parts of Igbo land – Nigeria[13].

This specie of AYB is gotten from Abagana, Anambra state.

Food legumes serve as an important economical source of supplementary protein for many populations lacking animal proteins. Most of the rural population cannot afford enough protein from animal source and this lead to growth retardation especially is children. Grain legume crops, of which African Yam Bean is one, solve the problem of inadequate protein intake (to a significant extent); because of their rich food protein content.

Africa Yam Bean is one of the lesser known legumes produced in Nigeria. Eneobong and Obizoba (1995) reported that diets based on African Yam Bean are nutritious and stressed the need for its reintroduction through increased production and appropriate processing technology. The lysine and methionine levels were reported to be equal or higher than those of soybean[4]. The protein content of African Yam Bean ranges from 19.6 – 29.0% according to and Akaninwor (2002) yet is in danger of extinction because of the high premium placed on the major legume crops such as cowpea, groundnut and soybean.

We are aware that food choices depend not only on nutrition and health considerations but also on factors such as individual likes and needs, local availability, cultural acceptability, etc. The objectives of this work therefore were to find out the proximate and functional properties of this particular AYB grown at Abagana, Anambra state of Nigeria and to ascertain its usefulness in food formulations.

MATERIAL AND METHODS

Materials

Odudu, a local variety of the African Yam Bean (Sphenostylis sternocarpa) seeds used for this study was obtained from the local traders at Abagana market in Anambra state of Nigeria, who harvested the produce from their farms.

Sample preparation

The Odudu (AYB) seeds were manually cleaned to remove extraneous materials and unwholesome seeds. The Cleaned seeds were soaked in tap water for 18hrs to facilitate the dehulling of the seeds. After careful dehulling, the seeds were sun-dried and ground into flour in a mill. Sieving was then carried out through a 0.5mm pore size sieve to obtain the dehulled White AYB flour and kept in a dry air tight plastic container for further analysis. The flow chart for the preparation of dehulled *Odudu* (AYB) flour is shown in Figure 1.

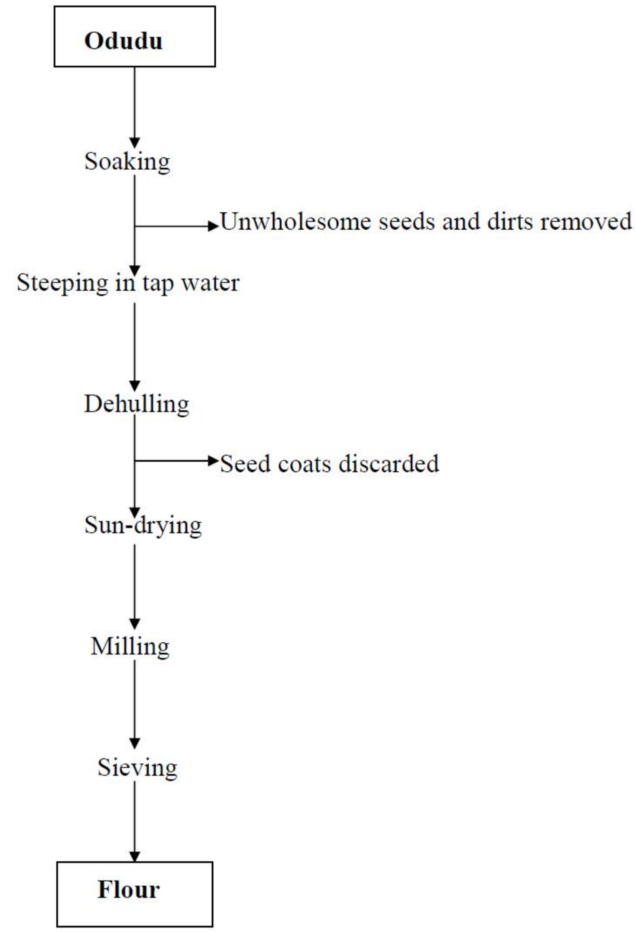

Figure 1: Flow diagram for the production of dehulled *Odudu* flour

Equipment and reagents

Some of the equipments and reagents used for this study were installed or provided at the Central Laboratory Unit of National Root Crops Research Institute, Umudike, Abia state - Nigeria. The rest were provided at the Food Lab of the Food Science and Technology department, Federal University of Technology – Owerri, Imo state, Nigeria. The equipments included centrifuge, mill, sieve, hot plate, muffle furnace, moisture extraction oven, measuring cylinder, conical flask, etc. Reagents used are as mentioned in the description of analyses within this manuscript.

Physical properties

Seed characteristics

Seed characteristics were determined following the procedure of[8]. The seeds were randomly selected then examined by subjective method for shape and texture, seed eye colour and testa attachment to the cotyledon. The degree of attachment of the testa was described as loose or firm depending on the resistance to peeling using fingers after soaking. The texture was described as smooth or wrinkled depending on how the seed appeared to the eye.

Seed size

Seed size were determined each of the randomly selected seeds for their length, width and thickness – all in millimeters using a vernier caliper[19]. The average size of the seeds was calculated.

Seed weight

Weight of a hundred seeds selected randomly was weighed as determined by the Association of Official Analytical Chemists (1984). The average seed weight was then calculated.

Proximate composition of dehulled white African Yam Bean flour

The procedures for analysis of the moisture, ash, crude protein, crude fibre, carbohydrate and fat contents were as outlined by the Association of Official Analytical Chemists[3].

Moisture content

Two grams (2g) of the sample was weighed into previously weighed aluminum dishes. These were deposited into a moisture extraction oven at 105°C for 3hrs. After three hours (3hrs.), the oven-dried samples in the dishes were transferred to a desiccator and allowed to cool and thereafter reweighed. They were then returned to the oven for further drying during which they were weighed at hourly intervals until there was no further reduction in weight (i.e. a constant weight was obtained). By weight differences, the weight of moisture was determined and expressed as a percentage of the initial sample weight. The formula below was used for calculation:

$$\%\text{ Moisture Content }(\%MC) = \frac{\text{Loss of Mass}}{\text{Initial mass of sample}} \times 100$$

Protein content

This was carried out using Kjedhal method as described by Chang[5]. The total Nitrogen (N_2) was determined and multiplied with factor 6.25 to obtain the protein content. Two grams (2g) of the flour sample was mixed with 10 ml of concentrated H_2SO_4 (Sulphuric acid) in a digestion flask. A tablet of selenium catalyst was added to it before it was heated in a fume chamber until a clear solution was obtained (i.e. the digest). The digest was diluted to 100ml in a volumetric flask and used for analysis: 10ml of 4% boric acid containing three (3) drops of mixed indicator (Bromocressol green and Methyl red). A total of 50ml of distillates was collected and titrated against 0.02N EDTA from green to a deep red end point. A reagent blank was also titrated to obtain the blank titre, and the percentage protein content was calculated using the formula below:

% Protein = % Nitrogen X 6.25

$$\%\ N_2 = (100/W) \times (N \times 14/1000) \times (Vt/Va)^{T-B};$$

W = Weight of sample (2g);

N = Normality of titrant (0.02N);

Vt = Total digest volume (100ml);

Va = Volume of digest analyzed (10ml);

B = Blank titre;

T = Sample titre value

Ash content

This was done by furnace incineration gravimetric method. 5g of the processed sample was measured into a previously weighed porcelain crucible. The sample was burnt to ashes in the muffle furnace at 650°C for 5 hours. When it has completely become ash, it was cooled in the dessicator and weighed. The weight of ash obtained was calculated by difference and expressed as a percentage of the weight of sample analyzed as shown below:

$$\%\ Ash = 100\ (W_2 - W_1) / \text{Initial weight of sample}$$

Where: W_1 **= Weight of empty crucible;**

W_2 **= Weight of crucible + ash**

Carbohydrate content

Carbohydrate content was obtained by difference. Calculation using the formula below was used as described by AOAC (1990).

% Carbohydrate = 100 – %moisture + %fat + %fibre + %ash.

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Fat content

The solvent extraction gravimetric method was used. 2g of the sample was wrapped in a paper (Whiteman filter paper) and put in a thimble. The thimble was placed in a Sohxlet reflux and mounted into a weighed (W_1) 250ml capacity extraction flask containing 200ml of hexane. The upper end of the reflux was heated, boiled, vaporized and condensed into the flask. In the process, the sample in the thimble was covered with solvent until the reflux flask is filled up and siphoned over, carrying its oil extract down to the boiling flask (extraction). After extraction, the flask is heated under reflux at 60°C for about 4hr to evaporate and condense the solvent bearing the extracted oil. After evaporation, the flask is further dried in the oven at 60°C for 30 minutes to remove any residual solvent. It flask was then cooled in a dessicator and weighed (W_2) with the "dried" oil contained.

% Fat = [(W_2 – W_1)/Weight of sample] x 100

Crude fibre content

Two grammes (2g) of the processed sample was boiled in 180ml of 1.25% H_2SO_4 solution for 30 minutes under reflux. The boiled sample was washed in several portions of hot water using two-fold muslin cloth to trap the particles. It was returned to the flask and boiled again in 150mls of 1.25% NaOH for another 30 minutes under some conditions. After washing in several portions of hot water, the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible and dried to a constant weight in the oven at 105°C. After cooling in a dessicator, the weight of the fibre was by difference and expressed as a percentage of the weight of sample analyzed.

%Crude fibre = 100(W_2 – W_3)/W_1

Where: W_2 = weight of crucible + weight of sample after boiling, washing and drying; W_3 = weight of crucible; W_1 = weight of sample used for the analysis.

Functional properties of dehulled white african yam bean flour

Wettability

The method of Ominawo and Akubor (2005) was adopted. Wettability was estimated by measuring the wetting time (seconds) of 1g of starch and flour sample dropped from a height of 15cm on the surface of 200cm^3 beakers at room temperature (3°± 2°C). 1g of the sample was weighed into a clean, dry test tube using a clean paper. The opening of the test tube was covered and the tube was clamped inverted in a retort stand 15cm over a 250cm^3 beaker containing 200cm^3 of distilled water at room temperature. Gently the paper covering the tube was removed and sample was allowed to fall under gravity into the beaker. The wetting time was recorded as the time (secs) required for all the flour to penetrate the surface of the still water and be wetted.

Bulk density

The method by Onwuka (2005) was adopted. 10ml capacity measuring cylinder was used. 5g of the flour sample (pulverized) was gently filled in the measuring cylinder. Then the bottom of the cylinder was softly tapped on the laboratory bench for several times until there was no further reduction of the height of the sample in the cylinder.

Calculation:

$$\textbf{Bulk density (g/ml)} = \frac{\textbf{Weight of sample (g)}}{\textbf{Volume of sample (ml)}}$$

Swelling index

One gram (1g) of the flour sample was transferred into a clean dry graduated cylinder. The flour sample was leveled and the volume noted. Distilled water was then added to the sample to make it up to 10ml in the cylinder. The cylinder was swirled and allowed to stand for 60 min (1hr), while the change in volume swelling was recorded every 15min. The swelling power of the flour sample was calculated as a ratio of the original volume to the final volume as done by Ukpabi and Ndimeli (1990).

Swelling Index = V_2/V_1

Where: V_1 = Initial volume occupied by the sample (after leveling the surface); V_2 = Volume occupied by the sample after swelling

Gelling and boiling points

This was determined according to the method of Naragam and Narasingo (1982). 5g (dry matter basis: dmb) of the flour sample was poured into a beaker to make 50ml suspension using distilled water. A thermometer was clamped on retort stand and submerged in the

TABLE 1: Physical properties of white African Yam Bean

Seed Colour	Eye Colour	Testa texture	Testa Attachment to Cotyledon	Average Seed Size L x W x T (mm^3)	Average Seed Weight(g)
White	Deep brown	Smooth	Firm	0.7 x 0.48 x 0.38	0.13

suspension while stirring was going on with a magnetic stirrer and the system heated. The heating and stirring continued until the suspension began to gel. Th e corresponding temperature was recorded, and the temperature at Boiling Point was also recorded.

Emulsion capacity

This was determined according to Yasumatus *et al.* (1972). 1g (dmb) of the sample was suspended in 10ml distilled water at room temperature and rapidly blended for 5min in a blender. Refined soy bean oil (10ml) was added gradually and blended rapidly for another 5min. The emulsion prepared was centrifuged at 2000 rpm (revolution per minute) for 5mins. The ratio of the total height of the emulsion layer to the total height of the fluid was calculated and emulsion capacity expressed as percentage.

$$\text{Emulsion Capacity} = \frac{\text{Height of emulsified layer in the tube X 100}}{\text{Height of the total fluid in the tube 1}}$$

Water/oil absorption capacity

The method described by Abbey and Ibeh (1988) was adopted for both properties. 1g each of the same flour sample was weighed separately into different clean and dry centrifuge tubes. Distilled water was added to one of the flour sample in the tubes and refined vegetable oil was added to the sample in the other tube to make each of them 10ml dispersions. The dispersions were then thoroughly mixed and centrifuged at 2,000rpm and thereafter allowed to stand for 30min at room temperature. The supernatant (water or oil) was decanted and the volume measured.

$$\textbf{Water Absorption Capacity (ml/g)} = \frac{\textbf{Volume of water decanted}}{\textbf{Weight of sample used}}$$

$$\textbf{Oil Absorption Capacity (ml/g)} = \frac{\textbf{Volume of oil decanted}}{\textbf{Weight of sample used}}$$

RESULT AND DISCUSSION

Result

The 8.50% moisture content of the dehulled white AYB flour was found to be within the specified range of not more than 14% moisture content for flour by Ihekoronye and Ngoddy (1985), hence, mould growth and possible bacterial action on the flour are not favoured, which will lead to a good keeping quality. The ash content of the flour was 3.43%, and this is also within specifications. Crude fibre is known to have good effect on metabolism in the gastrointestinal tract, and the 2.44% value for dehulled white AYB flour was found to be comparable with similar values from flours of other leguminous seeds. With 1.5% crude fat content, which is in conformity with the fat content of 1-2% by Summer and Roberts (1985), *Odudu* is not considered an oil seed. The crude protein content was estimated to be 22.48%, a value which agrees with the report of Eka and Akanimwor (2000) that the range for AYB flour is 19.6-29%. This 22.48% protein content indicates a significant value that could find relevance in infant foods formulation. Carbohydrates are sources of calories which serve as energy, and as such, the 61.65% carbohydrate content or less (considering the method of determination as some other micro-nutrients may still

TABLE 2: Mean values for proximate composition of the white variety AYB flour

Parameters (dmb)	Values (%)
Moisture	8.50 ± 0.21
Ash	3.43 ± 0.14
Crude Fibre	2.44 ± 0.01
Crude fat	1.50 ± 0.11
Protein	22.48 ± 0.10
Carbohydrate	61.65 ± 0.05

All values are expressed as mean ± SD (Standard Diviation).

TABLE 3: Mean value for functional properties of the dehulled white AYB flour

Components of Functional Properties	Values
Oil Absorption Capacity (ml oil/g flour)	0.8±0.01
Water Absorption Capacity (ml H_20/g flour)	1.8±0.02
Swelling Index (ml/g)	2.25±0.02
Emulsion Capacity (ml/g)	2.33±0.01
Bulk Density (g/ml)	0.89±0.01

be accounted for) was found to be acceptable.

Wettability is the time taken for the last particle of the flour to get wet, and it took 44.36secs thus making the flour a non-formidable instant powder in food products. With a swelling index of 2.25ml, the value obtained for the flour conforms to the swelling index of other legumes stated in the range from 1.1 – 3.0. The gelling temperature after the analysis was also recorded as 52°C while the boiling temperature was recorded as 64°C. The bulk density of AYB flour was 0.89g/ml. Emulsion capacity can be attributed to the protein in the flour. The emulsion capacity was found to be 2.33ml/g of the sample. Increased emulsion capacity can come about by increased proportion of solublized proteins[12]. Water absorption capacity is an important functional trait in foods such as doughs and sausages as it improves handling characteristics and maintains freshness in breads. The value for the flour was found to be 1.80ml/g. This value is desirable and could be due to the fact that the protein quality of the AYB is good and is able to bind large quantity of water as stated by Giami *et al.* (1992). The oil absorption capacity of the flour was found to be 0.8ml/g and this refers to the ability of protein in the floor to bind with fat since fat acts as flavour retainer, increases mouth fell of the food and performs well in extenders[9].

CONCLUSION AND RECOMMENDATION

Conclusion

The proximate composition of flour from white variety of African Yam Bean shows that the seed is a good source of protein and also carries the needed nutrients in fighting the protein-energy malnutrition in developing countries.

Recommendation

It is recommended that the white variety of African Yam Bean (*Odudu*) seeds be cultivated more since, even with high protein content and good functionality, the seed is still scarce. Also it can be evaluated for used in food formulation as a complement of cereal flour or used to prepare local foods such as *akara*.

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