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Evaluation of the Proximate and Functional Properties of Flours from Brown Variety of African Yam Bean (*Sphenostylis stenocarpa*) Seeds

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Authors' contributions

This work was carried out in collaboration among all authors. Author IMA designed the study, contributed to sample preparations and wrote the first draft of the manuscript. Author IAO helped to carry out the experiment. Author JCI performed the computations. Authors AEU and SOA managed the literature searches and interpreted the results. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To create variety of flours through food product development by checking the proximate and functional properties of flours from brown variety of African yam bean (*Sphenostylis stenocarpa*) seeds.
Study Design: This study was made to fit into a one way Analysis of Variance.
Place and Duration of Study: The research was carried out at the Department of Food Science and Technology laboratory, Federal University of Technology, Owerri, Nigeria, between July 2017 and September 2018.
Methodology: Brown coloured variety of African yam bean seeds were sorted, soaked, dehulled and milled to obtain full fat flour. The full fat flour was further processed to obtain defatted flour, protein isolate and protein concentrate. The different flours were analysed to determine their proximate and functional properties.
Results: From the results of the proximate composition, it showed that the protein isolate value

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89.1±0.23% was higher than the protein composition of the full fat, defatted and protein concentrates which has 21.8±0.16%, 23.1±0.06% and 61.7±0.21% composition respectively. There were no significant difference ($p<0.05$) between the protein concentrate, protein isolate, full fat flour and defatted flour. The functional properties revealed high bulk density of (0.50± 0.01) for the defatted flour more than the full fat flour (0.35± 0.10) while the emulsion capacity of the protein concentrate and protein isolate flour was found to be (30.7±0.19%) and (35.3± 0.16%) respectively.
Conclusion: The proximate and functional results obtained indicate that the starches from African yam bean will have useful technological properties for many applications both in food industries and in the production industries such as in paper and textile industries. It can also be said that African yam bean represents a source of alternative protein supplement and its protein isolates possess certain characteristics that will aid in protein enrichment for some food products.

Keywords: African yam bean; protein isolate; defatted flour; protein concentrates; enrichment.

1. INTRODUCTION

Legumes ranked as 3rd largest family of flowering plants having more than 19500 species and over 750 genera [1]. Legumes are very vital source of protein in the diet of population groups of many countries and also a vital of dietary protein in many countries including Nigeria [2]. African yam bean (AYB) is a herbaceous leguminous plant occurring throughout tropical Africa, known and called different names by different tribes in Nigeria; ijiriji or uzaaku in Igbo, Girigiri in Hausa and akpaka in Delta State. The African yam bean is known to have high protein, mineral and fibre content similar to most consumed legumes. It has high metabolic energy, low true protein digestibility (62.9%) and moderate mineral content. The amino and fatty acid contents are similar to those of most edible pulses and its economic potential has been known to help in reducing malnutrition among Africans [3]. However, African yam bean is underutilized and faces the danger of extinction in Nigeria because it has a beany flavor, takes time to cool and also has some anti nutritional factors which affect the nutrients [4] but these limitations can be overcome by processing techniques like fermentation, soaking, roasting among others [5]. The main aim of this work is to determine the proximate and functional properties of flour samples of brown coloured variety of African yam bean which include full fat flour, Defatted flour, protein isolate flour and protein concentrate flour which would be a form of dietary diversification leading to food security and sustainability in Nigeria.

2. MATERIALS AND METHODS

2.1 Source of Materials

The raw mature brown (speckle) coloured variety seed of African yam bean (*Sphenostylis stenocarpa*) was purchased from Mrs. Onwuchikwa Glory's farm in Abia State. All chemicals and equipments used for the analysis were of analytical grade and carried out at Federal University of Technology (FUTO) Owerri, Imo State.

2.2 Sample Preparation

The African yam beans were sorted with hands to remove stones, dirt's and spoiled seeds to obtain healthy ones.

2.2.1 Production of full fat AYB and defatted AYB flour

African yam bean seeds were soaked overnight (24 hours) in water at 1:5 (Water to volume) ratio. The seeds were manually dehulled to separate the seed coats from the cotyledon, then dried in the oven at temperature of 30°C for 48 hours, ground with a laboratory mill and sieved through 60 mm sieve to obtain flour sample. The full fat flour was soaked in ethanol at 1:5(water to volume) ratio and allowed to stand overnight at room temperature. The mixture was filtered with filteration apparatus, the fiterate which is the defatted flour was air dried for 8 hours and pulverized in a motor.

2.2.2 Production of AYB concentrate

The method of [6] was employed. The method involved defatting the flour with normal hexane (soaked for 3 hours and dried after sieving). The carbohydrate in the defatted flour (mainly sugars) was removed by extraction with ethanol for 30 minutes. The resulting defatted, carbohydrate free concentrate was dried in the oven at 45°C and used as the protein concentrate.

2.2.3 Production of AYB isolate

Seventy grams of defatted flour was added to 1400 ml of water to form a 1:20 (Water to volume) ratio of slurry. The solution was allowed to settle for 3 hours at a pH of 6.37. The spent residue was separated from the dissolved protein extract by decanting after which centrifugation took place. The pH of the extracted protein was adjusted with HCL to its iso-electric point between 4.0 -4.3. The precipitate formed was subsequently removed by centrifugation at room temperature by removing the whey which contains soluble sugars, residual protein, peptides, salt and minor constituents. The resulted curd (protein isolate) was then dried under air using desiccators before grinding and sieving.

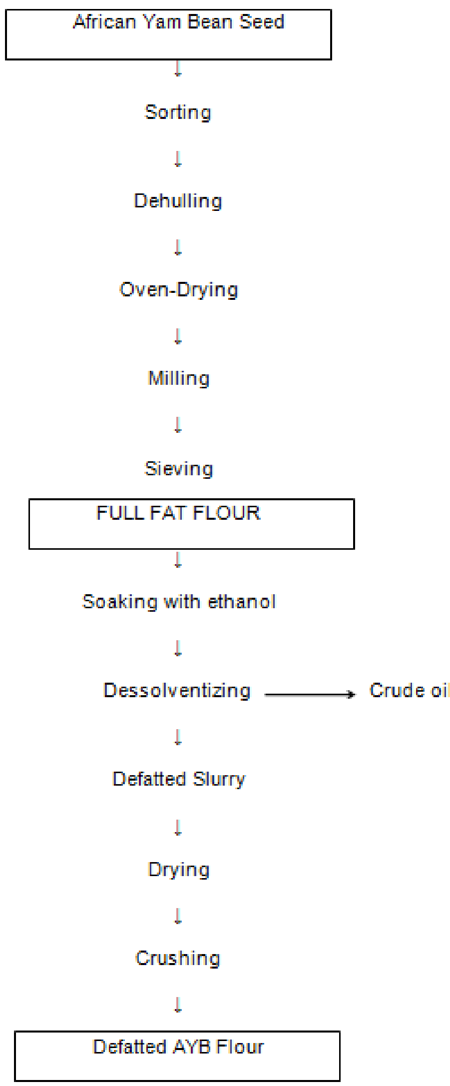

Fig. 1. Flow diagram for the production of full fat AYB flour and defatted AYB flour

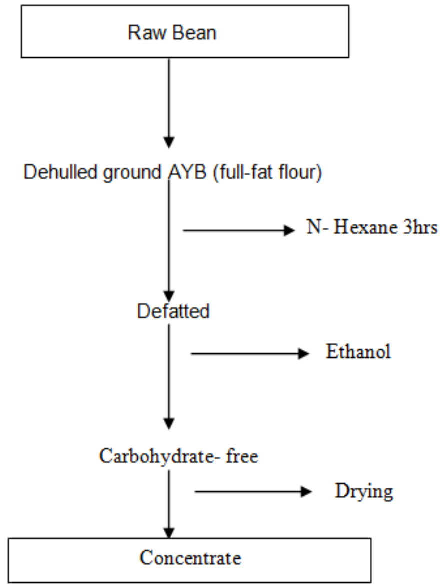

Fig. 2. Flow diagram for the production of protein concentrate from defatted African yam bean

2.3 Proximate Analysis

The proximate analysis was carried out according to the methods outlined by the Association of Official Analytical Chemists [7] was used for the determination of moisture content, fat, crude protein, crude fibre and ash while the carbohydrate content was calculated by their difference.

2.4 Determination of Functional Properties

The functional properties of the brown coloured African yam bean flour samples were determined using the method specified by [8] and [9].

2.4.1 Bulk density

The bulk density of the different flour samples was determined by the method of [8] and expressed as the ratio of the weight of the sample to its volume calculated as shown below;

$$\text{Bulk density} = w/v$$

where

w = weight of sample in gram
v = volume of sample in ml

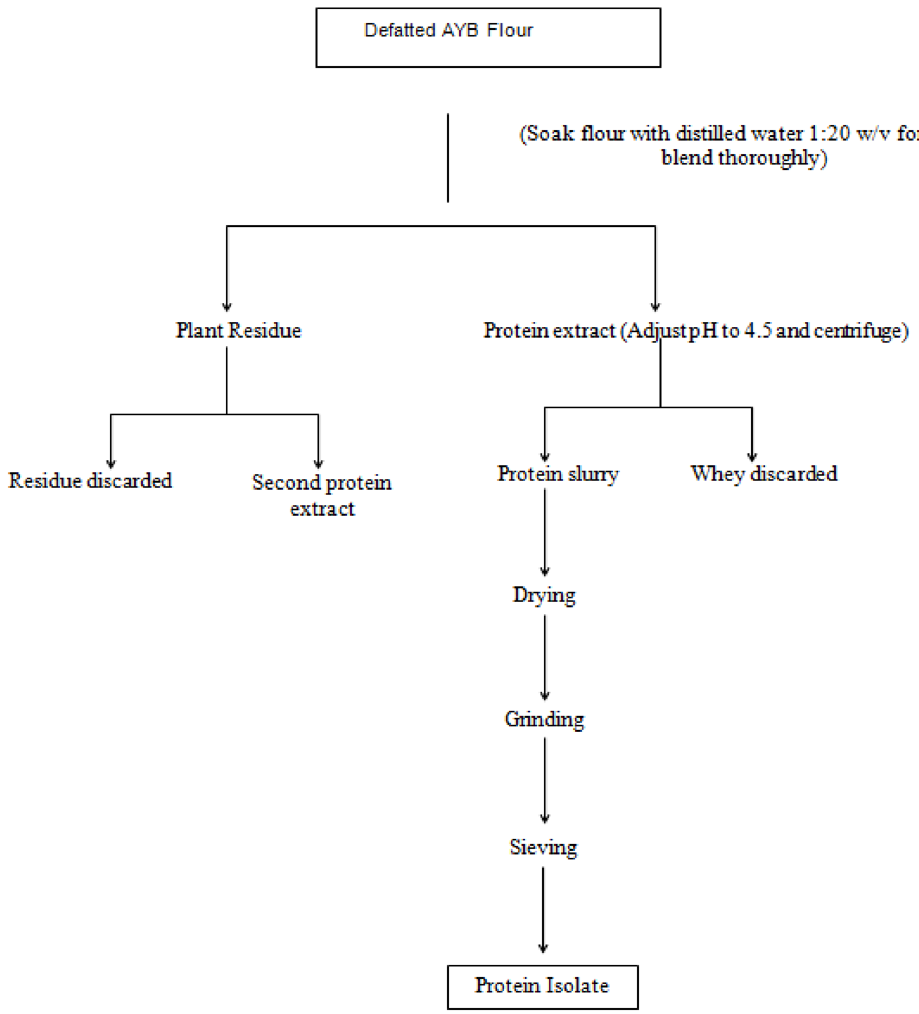

Fig. 3. Flow diagram for the production of protein isolate from defatted African yam bean

2.4.2 Water absorption capacity

This is determined as the weight of water absorbed and held by one gram of sample by the method prescribed by [8] and expressed as:

$$WAC = v1 - v2$$

V1= initial volume of distilled water
V2= final volume of the distilled water

2.4.3 Oil absorption capacity

This was determined in the same way as water absorption capacity.The oil absorption capacity was determined by difference, as the volume of oil absorbed and holds as 1gram of the sample shown below;

Oil absorption capacity = (initial volume of oil) – (final volume of the oil).

2.4.4 Gelation capacity

Five grams of sample was weighed into a beaker with 20 ml of water and heated until gelling point. The temperature at which it gels was measured using thermometer.

2.4.5 Emulsion capacity

The method used was described by [9] and was expressed as the amount of oil emulsified and held per gram of the sample. It is shown below;

Emulsion Capacity = Emulsion height / water height x 100

2.4.6 Swelling index

Swelling index was calculated using the method of [10] and calculated as the ratio of the final height and the initial height.

Swelling index = H2/H1

where

H2 = final height
H1 = initial height

2.4.7 Wettability

This was determined as the time in seconds taken by a unit weight (1 g) of the flour sample to get completely wet on the sample of water under laboratory conditions and the method used was described by [8].

2.5 Statistical Analysis

All the data were expressed as mean ± SD after three repeats. Data were subjected to one- way analysis of variance (ANOVA) with Fisher's least significant difference (LSD). The difference was considered to be significant while $P< 0.05$ analysed by IBM SPSS version 20 Software.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Flour Samples

Analysis was carried out on the proximate composition of the flour samples as soon as they were ready, in order to prevent loss of value due to deterioration. The proximate compositions of the test are shown in Table 1. The result revealed a high protein content of 21.83±0.16% of the full fat flour. [11] reported a protein content of 21.0- 29.0% for AYB full fat flour, although lower than most major legumes like soy bean (38- 44%), and African locust bean (23-27%). The result was found to fall within the range of other legumes including groundnut (21- 26%), pigeon pea (24.46± 0.31%) as reported by [12,13]. On the other hand, the African yam bean protein concentrate and isolate had an average protein content of 61.78% and 89.18% respectively.

This also compared favourably with (81- 91%) obtained for winged bean and 96.5% for the soy bean as reported by [9]. The ash contents of the protein concentrate (2.82±0.13%) and isolate (2.91±0.18) are significantly different at $p<0.05$. however, that of protein isolate is within the range by the report given by [9] for winged bean (3.4%) and lower for soy bean (5.5- 7.5%).

The full fat flour and the defatted flour contain fibre of (2.41±0.66) and (2.69±0.82%) respectively which slows down the release of glucose into the blood stream, hence high legume diet is recommended for diabetic patients. There was little or no traces of fibre and fat found in the protein concentrate and isolate of African yam beans. African yam bean concentrate an isolate was found to have values which were significantly different at ($p<0.05$) from those of full fat and defatted flour.

3.2 Functional Properties of the Flour Sample

The functional properties of the full fat flour and the defatted flour samples are shown in Table 2. The result revealed high bulk density of (0.50± 0.01) for the defatted flour. The higher bulk density of the defatted more than the full fat flour (0.35± 0.10) can be attributed to increase in density during processing bringing about significant differences of $p>0.05$ between the two samples. The foam capacity of the protein concentrate flour and protein isolate flour (4.28%) is significantly lower than that of the full fat flour (7.27%) and the defatted flour (9.73%). This means that the protein concentrate and protein isolate flour might not be able to retain stable foam when whipped and will not give the best results when used as an aerating or foaming agent in some food formulations like ice cream. The water absorption capacity of the protein concentrate and flour and protein isolate flour were significantly lower than that of the full fat flour and the defatted flour but the oil absorption capacity is higher. These results show that the capacity of food protein depends upon some intrinsic factor like amino acid composition, protein conformation and surface polarity or hydrophobicity [14]. The emulsion capacity of the protein concentrate and protein isolate flour was found to be (30.7±0.19%) and (35.32± 0.16%) respectively and they are comparatively lower than the full fat flour and defatted flour samples. The relatively low emulsion capacity of the protein concentrate and protein isolate flours could be attributed to the nature and type of protein materials and its constituents [15]. [16] reported that emulsion capacity and stability is higher in protein with globular nature and also the concentrate and isolate flour was found with a wettability of (2.53s) and (3.67s) per gram

Table 1. Proximate composition of full-fat, defatted flour, protein concentrate and protein isolate

Samples	Moisture	Protein	Fibre	Ash	Fat	Carbohydrate
Full fat flour	7.83^{a} ±0.42	21.8^{b}±0.16	2.41^{a}±0.66	2.18^{b}±0.24	6.32^{a}±0.03	59.4^{a}±0.12
Defatted flour	7.12^{c}±0.01	23.10^{b}±0.15	2.69^{a}±0.08	2.46^{c}±0.08	0.61^{b}±0.64	64.0^{a}±0.15
Protein concentrate	6.98^{b}±0.07	61.7^{a}±0.07	0.00^{c}	2.82^{a}±0.13	0.00^{c}	28.43^{b}±0.06
Protein isolate	6.47^{b}±0.36	89.1^{a}±0.23	0.00^{c}	2.19^{a}±0.18	0.00^{c}	1.46^{b}±0.21
LSD		0.326		0.337		0.292

All values are expressed as mean ± SD of their evaluation. Mean values within column with Superscripts are significantly different at ≤ 0.05

Table 2. Functional properties of full- fat flour, defatted flour, protein concentrate and protein isolate

Samples	BD	SW1	WAC	OAC	GT	EC	FC	W
Full fatted flour	0.35^{c}±0.10	1.13^{b}±0.42	1.34^{c}±0.11	1.51^{b}±0.70	16.00^{a}±0.02	90.2^{a}±0.16	7.27^{a}±0.63	0.50^{b}±0.74
Defatted flour	0.50^{c}±0.01	1.73^{c}±0.07	1.83^{a}±0.16	2.57^{b}±0.09	13.0^{a}±0.29	96.1^{a}±0.19	9.73^{a}±0.21	0.44^{b}±0.78
Protein concentrate	0.58^{a}±0.03	2.12^{a}±0.16	1.30^{b}±0.14	3.21^{a}±0.28	11.0^{b}±0.87	30.7^{b}±0.19	3.42^{b}±0.16	2.53^{a}±0.43
Protein isolate	0.67^{a}±0.08	2.43^{b}±0.33	1.71^{b}±0.10	3.62^{a}±0.51	10.0^{b}±0.01	35.3^{b}±0.16	4.28^{b}±0.11	3.67^{a}±0.11
LSD	0.136		0.258			0.349		

Where: BD= Bulk density; SW1=Swelling Index (ml/ml); WAC= Water Absorption Capacity (ml/g); OAC= Oil Absorption capacity (ml/g); GC = Gelling capacity (°C); EC= Emulsion capacity (%); FC= Foaming capacity (%) W= Wettability (sec) respectively.The full fat flour had a lower swelling capacity when compared with the protein concentrate and protein isolate flours which could be attributed to the extent of starch damage due to thermal and mechanical processes. According [17] the extent of swelling in the presence of water depends on the temperature, availability of water, starch species, extent of starch damage and other carbohydrates and protein. Also the swelling capacity of flours depends on size of particles, types of varieties and types of processing methods or unit operations. The gelling capacity of the full fat, defatted flour, protein concentrates and protein isolate samples were found to have no significant difference (p> 0.05). The full fat, defatted flour, protein concentrate and protein isolate flours were found to gel at temperature 95°C and 92°C, Nil and Nil respectively [16] associated the disparities in gelling properties to different components – proteins, lipids, and carbohydrate content of the legume. Protein was attributed to globulin fraction and gelling point is indeed an aggregation of denatured molecules. This property suggests that the full fat and defatted flours samples will be suitable in food systems such as pudding, sauces and moin-moin which require thickening and gelling properties and also important in the baking of bread and other flour products where it contributes to the desired bread crumb texture and structure of the product. The affinity of the flour samples for water also showed the water capacity of the four flour samples while the low values of the water absorption capacity of the analysed different flour samples suggest that African yam bean flour is less hydrophobic than other legume flours. Therefore, African yam bean flour have more useful functional ingredient in viscous foods like baked products, gravies, soup to increase viscosity. The oil absorption capacities of 1.51 g/ml and 2.57 g/ml for the full fat and defatted flour samples respectively are far lower when compared to other legumes. This result shows that the flavour retention capacity of African yam bean is less than other legumes of higher oil absorption capacity such as soy bean flour. This could be attributed to low hydrophobic protein in the African yam bean flour. Consequently, the low oil absorption capacity shows that it decreases the mouth feel when they are used as meat substitutes or meat analogues [14].

4. CONCLUSION

The result obtained from this study revealed great potential of African yam bean. The protein isolate was found to be very high in protein content, thus making it a potential source of quality protein comparable to those of legumes such as soy bean for the possibility of replacing animal protein with its protein. The proximate and functional obtained indicate that the starch will have useful technological properties for many applications both in food and non food uses such as in paper and textile industries. It can also be said that African yam bean represents a source of alternative protein supplement and its protein isolates possess characteristics which show that it could find its uses in different products as protein enrichment or texturizer. With the potential contribution of African yam bean to nutrition, it is therefore recommended that cultivation and utilization of this bean be encouraged while maximizing its processing. African yam bean should be incorporated into flour samples to form composite flours other foods, processed into flours as a complement to cereal flour while further work should be done on the shelf stability of the its flour and the suitability of the flour used in baking products like bread and biscuits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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