Full Length Research Paper

Physical, proximate and functional properties of 'Nsama' A local variety of African yam bean (*sphenostylis stenocarpa*) grown in southern states in Nigeria

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The physical, functional properties and proximate properties of "Nsama" a local variety of African Yam Bean obtained from Ikot-Akpan-Enin in Akwa-Ibom state were studied. The average seed weight and size were 0.13 ± 0.01 and 1.57 × 0.81 × 1.17 respectively. Results show that moisture, protein, fat content, crude fibre and ash content, for the dehulled (8.63%, 21.90%, 8.63%, 0.17%, 2.20%) and undehulled (6.34%, 20.43%, 8.22%, 0.03%, 3.26%) "Nsama" flour was significantly the same ($P < 0.05$). However, carbohydrate content dehulled (58.47%) and undehulled (61.72%) were significantly different. Gelation, water absorption capacity, for both the dehulled and the undehulled Nsama samples (5.00% and 6.00%, 1.73 ml/H_2O/g) were significantly the same ($P < 0.05$) while swelling index, emulsion capacity, bulk density and foaming capacity for the dehylled and undehulled samples (2.53 ml/mln and 2.49ml/ml, 2.38ml/g and 2.49 ml/g, 0.67 g/ml and 0.63g/ml, 36.00% and 40.20%) were significantly different.

Keywords: Nsama, African Yam Bean.

INTRODUCTION

Sphenostlies stenocarpa (Hochst ex A. Rich) Harms commonly referred to as African yam bean (AYB) belong to the family fabaccae-pea family. It is widely available in the Southern state of Nigeria. It contains protein content 19-22% (Ezueh, 1984; Ofuya et al., 1991) but grossly under-utilized. This plant is grown by peasant farmers as security crop. It is in danger of extinction because of the high premium placed on the major crop such as cowpea (Vigna unguiculata), groundnut (Arachis hypogeae), lima seed (Phaseolus linatus) and soyabean (Glycine max) (Klu et al., 2001).

The bean is used mainly as a pulse. The pulses are those species of legumes harvested traditionally for their seeds and are major sources of dietary protein and calories in food products throughout the world (FAO, 1982; Norton et al., 1985; Gami et al., 1992). The dry seeds serve as a source of protein in various preparations. The dry seeds are used in preparation of

special meals during the celebration of puberty rites for girls in the Avatine tradition, giving the crop a special role in the socio-cultural lives of the people. Its use as animal feed in some localities appears to be of minor importance to the low socio-economic group (which constitutes a larger percentage of the people among which there is a higher incidence of protein and energy malnutirition) (Akroyd and Doughty, 1969).

African yam bean (Sphenostylis stenocarpa) has many varieties. One of these is a local variety called "Nsama". Nsama is mostly consumed by the people of the southern states of Nigeria including the people of Ikot-Akpan Enin ans Ikot-Abasi Local Government Area of Akwa-Ibom State. This legume is cultivated primarily for its seeds. Planting of "Nsama" seeds is between April and harvesting starts 5 months after planting. The seeds are remobed from the pods after allowing it to dry in the field. Nsama is consumed as pottage alone or with boiled cassava known as "edita iwa" in Ibibio and other starchy foods like yam and plantain. These local African yam bean varieties (Nsama) unlike other variety requires staking and inter-planted with yams and cassava where

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they climb over yam stakes to height of about 3 m. The harvested seeds are highly susceptible to weevil's infestations especially at high humidity and temperate. The seeds are brown in colour and their consumption is restricted to the harvesting period after which their availability in the rural market becomes scarce. They are not cultivated in large quantity and their usages are limited.

The use of this bean variety is limited. Therefore, the objective of this study was to investigate the physical, proximate and functional properties of Nsama Sphenostylis stenocarpa (African yam bean) in order to ascertain its usefulness in formulation of foods.

MATERIALS AND METHODS

Materials

"Nsama" a local variety of the African yam bean (Sphenostylis stenocarpa) seeds used for this study were obtained from the farmers in February 2008. The Nsama seeds were obtained from Udua Ette, Akwa-Ibom State, Nigeria.

Sample preparation

The "Nsama" (AYB) seeds were manually cleaned to remove extraneous materials and unwholesome seeds. The cleared seeds were soaked in tap water for 3 days to facilitate the dehulling of the seeds. After Dehulling, the seeds were sun-dried and ground. The flour was kept in a dry, air-tight plastic container for further analysis. The flow chart for the preparation of Dehulling "Nsama" (AYB) flour is shown in figure 1.

Equipment

The equipments used for this study were installed at the Laboratory of Food Science and Technology, Federal University of Technology, Owerri. They include the centrifuge, hot plate, muffle furnace, moisture extraction oven etc.

Methods

Physical properties

Seed characteristics

The seed characteristics were determined following the procedure of Fashakin and Fasanga (1998). The raw seeds were randomly selected and then examined by subjective methods for shape, testa texture, seed colour,

eye colour and testa attachment to the cotyledon. The degree of attachment was described as loose or firm depending on the resistance of the testa to peeling using fingers after soaking. The texture was described as smooth or wrinkle depending on how the seed appears to the eyes.

Seed size

The size of seed was dimensionally characterized by measuring each of ten randomly picked seeds for their length (L), width (W), and thickness (T) in mm using a Vernier Caliper of about 0.01 mm precision (Zibokere, 1994). The average seed size was calculated.

Seed weight

Weight of 100 seeds randomly selected was determined by weighing (AOAC, 1984). The average seed weight was calculated.

Proximate composition

The procedure for the chemical analysis for the moisture, ash, crude protein, crude fibre, carbohydrate and fat were as outlined by the Association of Official Analytical Chemist (AOAC, 1980).

Moisture content

Two grams of sample (AYB flour) were weighed into dried and weighed aluminum dishes. The samples were put into a moisture extraction oven at 105^0C for 3 hours. The samples were transferred to a dessicator and allowed to cool and weighed. The samples were re-dried, cooled and weighed until a constant was obtained. The moisture content was calculated on percentage basis as follows:

$$\% \text{ Moisture content (\% M.C)} = \frac{\text{Loss in mass}}{\text{Original mass of sample}} \times 100$$

Ash content

Two grams of samples were weighed into ignited, cooled and weighed crucibles. The samples in the crucibles were placed in a muffle furnace at 550^0C for 3 hrs until the samples turned white and free of carbon. The crucibles with the ash samples were cooled in the dessicator and weighed. The ash content was calculated as;
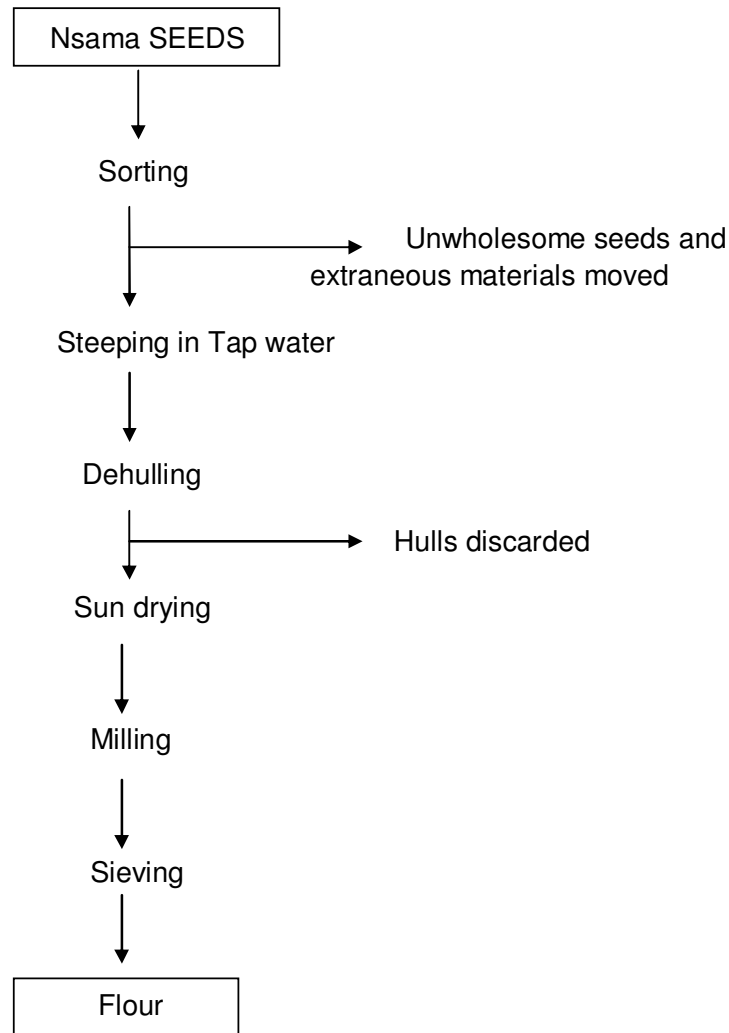
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┌─────────────────┐
│   Nsama SEEDS   │
└─────────────────┘
         │
         ▼
      Sorting
         │
         ├──────────────────▶  Unwholesome seeds and
         │                     extraneous materials moved
         ▼
  Steeping in Tap water
         │
         ▼
      Dehulling
         │
         ├──────────────────▶  Hulls discarded
         ▼
    Sun drying
         │
         ▼
      Milling
         │
         ▼
      Sieving
         │
         ▼
┌─────────────────┐
│     Flour       │
└─────────────────┘
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Figure 1.   Flow diagram of the production of "Nsama" flour

$$\% \text{ Ash } = \frac{\text{Mass of Ash } \times 100}{\text{Original mass of sample}}$$

Crude fat content

A soxhlet extraction unit with a reflux condenser and a small round bottom flask (250 ml) was fixed up. The flask was weighed after washing and drying and half filled with petroleum ether (B.P 40 – 60^{0}C) and fitted back to the unit. Two grams of each samples was weighed and wrapped with a whatman paper and gradually lowered into the thimble which was fitted to a cleaned, dried and weighed round bottom flask containing 120 ml of petroleum ether. The sample was slowly heated with a heating mantle for 5 hrs. Refluxed petroleum ether was recovered and the flask containing the fat was dried in the moisture extraction oven at 60^{0}C for 5 min to remove any residual solvent. After drying, the flask containing the fat was cooled in a dessicator and weighed. The mass of fat extracted was determined as;

$$\% \text{ Crude fat } = \frac{\text{Mass of fat } \times 100}{\text{Mass of sample}}$$

Crude fibre content

Two grams of the samples were measured and transferred into a 600 ml Erlenmeyyer flask. Two hundred millitres of 1.25% sulphuric acid and 1 g of antifoaming agent were also added. The contents were allowed to boil for 30 min. At the end of the 30 min the mixture was allowed to stand for 1 min, and filtered immediately through the Buchner funnel lined with muslin cloth. The insoluble matter was washed into the flask for alkali digestion using 0.3 m sodium hydroxide. The digest was

boiled for 30 min and was allowed to cool for 1 min and filtered using the muslin cloth as before. The residue was washed successively with boiling water. 0.1 m HCL and finally with boiling water until it was freed of acid. It was washed twice with alcohol and thrice with ether. The residue was transferred into a crucible and dried at 100^0C in an oven to a constant weight. The difference in weight after washing was taken as the fibre constant of the sample and was expressed as a percentage of the original weighed sample and calculated thus;

% Crude fibre = $\dfrac{\text{Oven dry weight – weight after ashing}}{\text{Weight of sample}} \times 100$

Crude protein content

Into a digest flask was placed 0.1 g of sample and 0.8 g of catalyst mixture (copper and sodium sulphate) were added and 20 ml of conc. H_2SO_4. The flask was swirled to mix the contents. The mixture was heated gently in the digestion stand in th fume chamber until the mixture became clear. After digestion and subsequent cooling, the solution was transferred into a 25 ml volumetric flask and made up to mark with distilled water. This was distillation apparatus and distilled with 35 ml of 40% sodium hydroxide. To the receiving flask, 10 ml of 2% boric acid, 2 drops of methylene red indicator were mixed. The distillation until was connected to the delivery tube dipped below the surface of the boric acid solution. The distillation was collected up to 75 ml and titrated with 0.1 N hydrochloric acid. The crude protein was determined by multiplying the empirical factor by 6.25.

% Nitrogen (N_2) = $\dfrac{(T - B) \times NHCL \times 0.00014 \times \text{Vol. Made} \times 100}{\text{Aliquot} \times \text{ weight of sample used}}$

% Crude protein = $6.25 \times N_2$
Where;
T = Acid titre value
B = Blank titre value
NHCL = Normality of HCl used
Aliquot = Sample of aliquot taken
Volume made = 100 ml

Carbohydrate content

Carbohydrate content was by difference. This was done by summing the moisture content, protein, fat, ash and crude fibre contents and then subtracted by 100.
% Carbohydrate = 100 − (moisture + crude protein + crude fibre + crude fat)

Functional properties of the AYB flour samples

Water and oil absorption capacity

The method of Carcea Benecini (1986) was used. One gram of the AYB flour sample was stirred in 10 ml of distilled water/oil for 1 min by manual shaking. The mixture was then allowed to stand at room temperature for 30 min and centrifuged at 1,500 rpm for 30 min. The supernatant was decanted and the volume in the measuring cylinder was noted and converted to weight (in grams) by multiplying by the density of oil (0.902 g/ml) and water (1 g/ml) respectively. The oil/water absorption capacities were expressed as grams of oil/water absorbed per gram of flour sample.

Gelation capacity

The gelation capacity of the flour samples was determined according to the method of Onwuka (2005). Sample suspensions 2 – 20% (w/v) were prepared in 5 ml distilled water in test tubes. The last tubes containing these suspensions were heated for 1 hr in a boiling water bath, followed by rapid cooling under running cold tap water and the test tubes were further cooled for 2 hrs at 40^0C. The gelation capacity was determined as the least gelation concentration when the sample from the sample from the inverted test tubes did not fall or slip.

Emulsion capacity

The procedure of Beuchat et al., (1975) was adapted as described by Eke (2000). Two grams of flour sample and 75 ml of distilled water blended for 30s using a magnetic stirrer. After complete dispersion deodorized vegetable oil was added continuously through a burette until emulsion breakpoint, separation into two layers was reached. The emulsion capacity was expressed as ml of oil emulsified per g of flour.

Bulk density

The method of Onwuka (2005) was followed. A 10 ml graduated measuring cylinder was weighed and filled gently with the flour samples. The bottom of cylinder was tapped gently on laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. The bulk density was calculated as;

Bulk Density (g/ml) = $\dfrac{\text{Weight of sample(g)}}{\text{Volume of sample (ml)}}$

Swelling index

The method of Abbey and Ibeh (1988) was employed. One gram of the flour samples were weighed into 10 ml graduation measuring cylinder. Five milliliters of distilled water was carefully added and the volume occupied by the sample was recorded. The sample was allowed to

Table 1. Physical properties of African Yam Bean Seed

Seed colour Average seed	Eye colour	Testa texture	Testa attachment to cotyledon	Seed siz (L×W×T)mm weight (g)
Brown 0.3±0.01	white eye	smooth	Firm	1.57×0.81×1.17

Table 2. Mean values for proximate composition of African Yam Bean Seed

Components (dry weight basis)	Dehulled Nsama seed (%)	Undehulled Nsama seed (%)
Moisture	8.63 ± 0.70a	6.34 ± 0.06b
Protein	21.90 ± 0.20a	20.43 ± 0.02b
Crude fat	8.63 ± 0.10a	8.22 ± 0.10b
Crude fibre	0.17 ± 0.01a	0.03 ± 0.01b
Ash	2.20 ± 0.10a	3.26 ± 0.10b
Carbohydrate (by difference)	58.47 ± 0.10a	61.72 ± 0.10a

* a – c Means with the same superscript among row are statistically equal at $p = 0.05$

stand undistributed in water for 1 hr and the volume was again recorded. The swelling index was calculated as the ratio of the volume occupied after swelling.

Swelling index = $\dfrac{\text{Volume occupied by sample after swelling}}{\text{Volume occupied by sample before swelling}}$

Foaming capacity

The foaming capacities of flour samples were determined according to Onwuka (2005). Two grams of samples was blended with 100 ml distilled water in an electric blender for 30 min. The mixture was transferred into a 250 ml measuring cylinder and the volume after 30s was recorded. The foam capacity was expressed as percent increase in volume using the formula of Abbey and Ibeh (1988) as reported by Onwuka (2005).

Foaming capacity = $\dfrac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume before whipping}} \times \dfrac{100}{1}$

Statistical analysis

All analysis was carried out in triplicate. Values from proximate composition and functional properties were statistically analyzed using Analysis of Variance (ANOVA) procedure to determine the significance of the factor means according to Steel and Torrie (1980). In the tests where the variance ratios (F values) proved significant, Fisher's Least Significant Difference (LSD) procedure (Roessler, 1984) was used to separate the factor means.

RESULTS AND DISCUSSIONS

Physical properties

The results of physical properties of the (AYB) seed were presented in Table 1. The seed were all brown in colour, and had white eye. The (AYB) seeds in the testa texture had smooth testa and were firmly attached to the cotyledons. The average seed weight was 0.13 g and the values correspond to the range of 0.13 to 0.22 g reported by Marcone et al., (1990). The length of the seed ranged from 3.10 to 3.30 mm, width from 5.0 to 5.8 mm and thickness was from 3.10 to 3.9 mm. These results corresponded with the report of Purseglove (1974) who found that (AYB) seeds vary in size, colour, 2 to 12 mm long, smooth or wrinkled, brown spotted (specked). The result was also not in agreement with the report of Maria et al., (2000) who reported the length range of 6.7 to 11.2 mm and width of 5.3 to 8.2 mm for (AYB) seeds.

Proximate composition

The moisture content of the undehulled (AYB) flour was found to be 6.3% and this was in agreement with the report of Ene-Obong and Carnovale, (1992) who reported values for African Yam species. The dehulled (AYB) flour had a higher moisture content of 8.63%. The moisture content of the dehulled (AYB) flour was very significant ($P < 0.05$) and this was attributed to the long soaking period prior to Dehulling. This moisture content was desirable because if the moisture content of flour is more than 14%, there is a danger of bacteria action and mould

Table 3. Mean values for functional properties of African Yam Bean Seed

	Water absorption capacity (ml H_2O/g Flour)	Oil absorption capacity (ml H_2O/g Flour)	Swelling index (ml/ml)	Emulsion capacity (Ml/g)	Bulk density (Ml/g)	Gelation capacity (%)
Foaming Capacity						
Dehulled 36.0±5.1a	1.73±0.01a	0.73±0.01a	2.53±0.03a	2.53±0.03a	0.67±0.1a	5.0±2.0a
Undehulled 40.2±4.0a	1.4±0.10a	0.50±0.10b	2.49±0.10a	2.48±0.10a	0.63±1.0a	6.0±2.0b

Table 4. Gelation capacity of "Nsama" seed flour in water at different concentration

Concentration g/100 ml	GC in H_2O
1	-
2	-
4	-
6	+
8	+
10	+
12	+
14	+
16	+
18	+
20	+

growth and such flour will keep badly and develop hydrolytic rancidity (Ihkoronye and Ngoddy, 1985).

The crude protein for the dehulled (AYB) flour was significant different (P < 0.05). The flour from the undehulled (AYB) seed had good protein contents although the dehulled flour had higher protein (21.90%) than the undehulled (20.50%) and this was attributed to the soaking and Dehulling operations given to the dehulled seeds. This was in agreement with the report of Ezema (1989) which showed that dehulling increased the protein contents of legumes. The fat content for the (AYB) flour were significant (P < 0.05) with values ranging from 8.63 to 8.22 for the undehulled and the dehulled samples respectively, which fits into the established values already reported by Oshodi et al., (1995). The crude fibre for the (AYB) flour was 0.17% for the dehulled and 0.03% for the undehulled. The fibre values were in agreement with that of Ene-Obong and Carnovale (1992) who reported that (AYB) flour contains 0.02 to 3.4%. The carbohydrate content for the dehulled flour was found to be 58.47% and the undehulled 61.72%. This value fits into the report of Oshodi et al., (1992) which had 48.1 to 63.50% and were desirable since carbohydrate is a source of calorie.

Functional properties of (ayb) flour

The results of analysis from the (AYB) seed on the functional properties of (AYB) flour were reported in Table 3. The details of the statistical analysis of the data were reported on Appendices.

Water and oil absorption capacity

The (AYB) flour had a water-absorption capacity of 1.73 ml H_2O/g for the dehulled and 1.40 for the undehulled samples. The samples were statistically significant (P < 0.05); this may be due to increased proportion of proteins. Water absorption characteristics represent the ability of the product to associate with water under conditions where water is limiting (e.g. Dough and Pastes). The values were within the range of 1.4 to 1.9 m/H_2O/g reported by Akpapunam et al., (1996). Studies by Wolf (1970) showed that this property enabled bakers to add more water to dough and so improve handling characteristics and maintain freshness in breeds. The ability of proteins to bind fat is important since fat acts as flavor retainer and increased the mouth-feel of foods

(Gianmi et al., 1992).

Swelling index

The swelling index for the dehulled Nsama seeds was above and this was in agreement with the range of 1.1 to 3.0 of the swelling index of different (AYB) flours.

Emulsion capacity

The result presented in Table 3, that is, 2.53 to 2.49 for dehulled and undehulled showed that they were not significant (P < 0.05). The values agree with the range of 2.0 2.55 reported by (Pawa and Ingle, 1988). The increase in emulsion capacity may be attributedto increased proportion of solubilized proteins (Narayama and Rao, 1982).

Bulk density

(AYB) flour was found to have bulk density values of 0.67 g/ml (dehulled) and they were not significant.

Gelation capacity

The local gelation concentration for the undehulled Nsama was 6% w/w. The gelation capacity was significantly different (P < 0.05). The low gelling concentration in this study indicated that gelation is not only dependent on the quantity of protein in the flour but seemed also to be related to the type of protein as well as the non-protein components and protein solubility and this was similar to the conclusion reached by Sathe and Solunkle (1981) in their study on great northern bean. This result indicates that (AYB) flours would be used in th formulations which require thickening.

Foaming capacity

The foam capacity of the flours ranged from 36 to 40.20 for both dehulled and undehulled samples were significantly different (P < 0.05) and they showed a good foam capacity. This property would make the flour useful as an acrating agents in food systems such as whipped toppings, mixes, 'akara and moi-moi' products which require the production of stapled high volumes when whipped (Giami et al., 1992).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The result of the composition of Nsama flour (both dehulled and undehulled) shows that the seed is a good source of protein therefore has great potential in combating the protein-energy malnutrition in developing countries.

Recommendations

As a result of the high protein content and good functionality of the Nsama seeds, the seeds would be a good substitute for flour hence their cultivation should be encouraged. They could also be used in "moi-moi, akara" baked product and soup as they would provide good fat binding emulsification and foaming capacity.

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