Influence of Processing Techniques on the Anti-nutritional, Functional and Proximate Properties of African Yam Bean

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ABSTRACT

African yam bean is an important tuberous legume, known for its nutritional importance in the tropical Africa. The study investigated the influence of processing techniques on the anti-nutritional, functional and proximate properties of African yam bean. African yam bean was subjected to different processing techniques which were boiling, roasting, autoclavingand de-hulling, while control sample was not subjected to any process technique.Anti-nutritional, functional and proximate analyses were carried out using the standard methods. The results of the proximate analysis showed (9.50, 10.50, 4.20, 11.97, 11.40%), (21.93, 27.00, 28.39, 27.19 and 28.38%) and (5.97, 5.90, 7.64, 4.99 and 1.99) for moisture, protein and crude fibre, respectively of the control, boiled, roasted, autoclaved and de-hulled African yam beans. The results showed significant difference with respect of the processing techniques, while the roasted and de-hulled African yam beans showed the highest protein contents. The results of the functional analysis showed (186, 240, 220, 220 and 250%), (100, 120, 110, 128, 120%) and (2.30, 0.38, 0.56, 1.39 and 2.20%) for water absorption capacity, oil absorption capacity and solubility, respectively of the control, boiled, roasted, autoclaved and de-hulled African yam beans. The results of the anti-nutritional analysis showed (0.39, 0.419, 0.254, 0.327 and 0.346 mg/kg), (2255, 1485, 1100, 990 and 1430 mg/kg) and (737.50, 550.00, 2300.00, 625.00 and 187.50 mg/kg) for phytate, oxalate and tannin, respectively of the control, boiled, roasted, autoclaved and de-hulled African yam beans. Results showed that roasted and de-hulled African yam bean has the least phytate and oxalate contents, respectively.

Keywords: African yam bean, autoclaving, boiling, de-hulling, roasting

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1. INTRODUCTION

Protein calorie malnutrition is one of the major problems of the developing world, especially among the children and the nursing mothers [1]. The increase in population and cost have also posed a great threat to the availability and accessibility of animal protein for human nutrition, hence the need for alternative plant source [2].Harnessing plant protein from many legumes source to substitute for the costly and available animal protein will solve the problem since various legumes are diversified in the quality and quantity of the available essential amino acid present in them [3].African yam Bean which is peculiarly regarded as underutilized crop due to its low esteem and lack of detailed information on its compositional analysis is a leguminous food crop which can supplement the protein requirement of many families throughout the year[1].This legume has been reported to be of importance in the management of chronic diseases like diabetes, hypertension and cardiovascular diseases because of its high

dietary fibre content [4]. It produces an appreciable yield under diverse environmental conditions while the seed and tuber contain different food fraction and minerals that is comparable to other food legumes [5]. Owing to its high protein content, it has been reported to be ranked well among neglected crops and can contribute to food security if its genetic resources are saved for utilization in breeding [1].The positive contribution of African yam bean to food security is the identification of the presence of lectin in the seeds, which could be a potent biological control for most leguminous pests [3].

The suitability of African yam bean for the diverse ecologies suggests that it can potentially serve as an important crop for food security since it can tolerate varied soil and climatic conditions [6]. This quality confers an ecological advantage over most conventional legumes [7]. Contrary to the remark of [8] on the nearness of the crop to extinction, the ability of the crop to survive in diverse agro ecological conditions of Africa must have aided its continual existence over times [5]. In most West African communities, the seed grains are boiled and eaten with other staples such as yam, plantain, cassava, corn/maize, etc.Cooked seeds of African yam bean have been reported to have higher fibre content, high efficiency of protein digestibility, higher amino acid availability, high gross and metabolizable energy and good fatty acid profile [3]. Food processing techniques provides alternative means of improving the quality of food [9] and the digestibility of protein in leguminous grains [10].Long-time cooking gave the highest digestibility value in African yam bean; the thermal process destroys protease inhibitors and opens the protein structure though denaturation breaks down the anti-nutritional factors which denatures the proteins/enzymes and gelatinizes the starch for adequate digestibility [11]. Although the various processing techniques positively influence the physiochemical properties of African yam bean such that the processed meal were of significant nutritional superiority over the unprocessed ones [10],nevertheless most of the techniques, significantly cost high loses in protein, calcium, phosphorus compound (e.g. phytin-phosphorus) and phytic acid.Fermentation can substantially improve the nutritional quality of African yam bean (7, 9] and reduce losses (due to thermal influence) of most food values. The bacteria encountered during natural fermentation of African yam bean seeds include *lactobacillus jejuni, Bacillus coagulans,Aerococcous viridians*and*Pedicoccouscerevisae.* Naturally, the raw seeds of African yam bean were found to contain *Lactobaccilusjensenii, Bacillus coagulans, Acrococus viridians, Canadidamycoderm.* The high aerobic count might be due to high protein contain in African yam bean. These bacteria produced enzymes which degraded and built up nutrients in African yam bean with organoleptic quality as condiment [9]. The objective of the present study therefore was to evaluate influence of processing techniques on the anti-nutritional, functional and proximate properties of African yam bean.

2. MATERIALS AND METHODS

2.1 Materials

African yam beans were obtained from Kaduna, Nigeria and processed into four different techniques: roasting, boiling, autoclaving and de-hulling while the fifth sample which served as the control is left unprocessed.

2.2 Methods

African yam beans were roasted in a pot mixed with clean fine sand after which they were milled into flour.African yam beans were also autoclaved at 121 ^{0}C for 30 min, dried at 62.8 ^{0}C for 8 h and milled into flour. African yam beans were pre-soaked for 20 min to facilitate bean hydration before boiling. The beans were boiled at 100 ^{0}C for 90 min; the beans were oven dried at 62.8 ^{0}C for 8 h and milled into flour. African yam beans were pre-soaked for 48 h to soften the seed coat and then de-hulled. The beans were oven dried at 62.8^{0}C for8 hand milled into flour.

2.3 Analyses

2.3.1 Determination of proximate composition

Analysis of moisture content, crude protein, crude fat, ash and crude fibre were determined by method described by [12]. Total carbohydrate content was determined by subtracting the crude protein, fat, ash and crude fibre percentages from 100%.

2.3.2 Determination of functional properties

2.3.2.1 Determination of bulk density

Bulk density was determined using the gravimetric method described by [13]. Each sample (10 g) of the flour was weighed into a 25 ml graduated cylinder. The cylinder was gently tapped 10 times against the palm of the hand. The bulk density was expressed as the sample per volume occupied by the sample.

2.3.2.2 Determination of water absorption capacity

Water absorption was determined by the modified centrifuge method of [14]. Each sample (M_0) was transferred into a lagged 50 centrifuge tube and weighed as (M_1), while 30 ml of distilled water at 70 °C was added to each sample, the sample and the water was mixed thoroughly for 30 min. The suspension was allowed to rest for 10 min and centrifuged at1165 rpm for 25 min at 50 ^{0}C (the centrifuge used was refrigerated and so it made easy to control the temperature). The tube was cooled in a desiccator and weighed as (M_2).

$$\text{Water Absorption} = \frac{\text{M2} - \text{M1}}{Mo}$$

2.3.2.3 Determination of oil absorption capacity

Oil absorption capacity of the flour samples was determined by the centrifugal method described by [15] with slight modifications. One gram of sample was mixed with 10 ml of pure canola oil for 1 min, the mixture was allowed to stand for 10 min at room temperature, centrifuged at 4000 g for 30 min and the oil that separated was carefully decanted and the tubes were allowed to drain at a 45° angle for 10 min and then weighed. Oil absorption was expressed as percentage increase of the sample weight.

2.3.2.4 Determination of emulsion capacity

Emulsion capacity of the flour samples was determined by the method described by [16] with slight modifications. Sample was prepared (25 g) at concentration of 1,2,3,4,and 5% w/v forming slurry was weighed at 0.25, 0.50, 0.75, 1.00 and 1.25g was placed into the beaker respectively and was dissolved each in distilled water. Oil was added gradually from the burette at the rate of 1ml/sec into the sample and was stirred continuously. The volume was noted at the point when emulsion occurred.

2.3.2.5 Determination of foaming capacity and foaming stability

Flour sample was weighed into a graduated beaker containing 100ml of distilled water. The initial volume of water was recorded as V_1. The Sample was homogenized at a high speed using a homogenizer and the content was poured quickly into a graduated cylinder. The total volume was recorded as V_2.

$$\text{Foaming capacity}\,\% = \frac{\text{V2} - \text{V1}}{V1}\ x100$$

For foaming stability, the cylinder was allowed to stand for 30min,1 , 2 ,3 , 4 , 5 and 6 h each interval was recorded as the total volume.

$$\text{Foaming stability}\,\% = \frac{\text{foaming volume after time (t) x 100}}{initial\ foaming\ volume}$$

2.3.2.6 Determination of least gelation

The least gelation concentration (LGC) was evaluated using a method described by [17] with modification. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30 % (w/v) prepared in 5 ml distilled water was heated at 90 °C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2 °C. The least gelation concentration was determined at the concentration when the sample from inverted tube did not slip.

2.3.2.7 Determination of solubility and swelling capacity

Solubility were determined on flour samples at 60, 70, 80 and 90 ^{0}C using a modified version of the method described by [18. 19]. Briefly, 40 ml of 1% starch suspension (w/v) was prepared in a previously tarred, 50 ml centrifuge tube. The tube was slowly shaken to keep the starch agitated and the temperature (60, 70, 80 and 90 ^{0}C) was maintained constantly in water bath for 30 min. The suspension was then centrifuged at 3500 rpm for 20 min, the supernatant decanted and the swollen granules weighed. From the supernatant, 10 ml were dried in an air convention oven at 120 ^{0}C for 4hrs in a crucible to constant weight. Swelling power was expressed as the weight of swollen granules (final weight) divided by the initial weight. Percentage solubility was calculated thus:

$$\%\ Solubility = \frac{dry\ weight.\ at\ 120\ ^0C}{Sample\ weight} X\ 100$$

2.3.3Determination of Anti-nutritional Properties

2.3.3,1 Determination of tannin

Gravimetric determination of tannin was done according to the method of [20]. A well-blended sample (1 g) was weighed into a flask while 10ml of water was added and agitated. It was left to stand for 30min at room temperature. It was centrifuged at 2500rpm for 15 min and 2.5ml of supernatant was measured into a 50ml volumetric flask,1ml of folin Dennis reagent and 2.5ml of Na_2CO_3 solution was added. The solution was diluted to 50ml with distilled water and incubated for 90min at room temperature.

$$Tannin\ \left(\frac{mg}{kg}\right) = \frac{Conc.\ Obtained\ in \frac{mg}{l}\ x\ volume\ of\ sample}{Sample\ weight}$$

2.3.3.2 Determination of trypsin inhibitor

Trypsin inhibitor was determined using method described by [21] with modification. A well-blended sample (1 g) was weighed into a 50ml flask and 0.5M NaCl was added and stirred for 30min. It was centrifuged at 1500rpm for 5min and decanted; while 10ml of filtrate was pipette into another flask,2ml of standard trypsin solution of known concentration was added to the 10ml filtrate. The absorbance was measured at 410nm using 10ml of the same substrate as blank: 2, 4, 6, 8, and 10mg/l standard trypsin inhibitor was added and their absorbance read at 410nm.

$$Trypsin\ inhibitor\ \left(\frac{mg}{kg}\right) = \frac{Conc.\ Obtained\ in \frac{mg}{l}\ x\ volume\ of\ sample}{Sample\ weight}$$

2.3.3.3 Determination of phytate

Phytate was determined using method described by[22] with modification.Sample (2g) were weighed into 250ml conical flask, 100ml of 2% concentrated HCl was added and allowed to soak for 3 h and then filtered. 50ml of filtrate was pipette into 250ml beaker and 107ml of distilled water was added to improve acidity and 10ml of ammoniumthycyanate solution was added as indicator. The sample was titrated with standard iron III chloride ($FeCl_3$) solution which contained 0.00195 iron/ml until a brownish yellow colour appear and persisted for 5min.

$$Phytic\ acid\ \left(\frac{mg}{kg}\right) = \frac{0.00195\ x\ \ Volume\ of\ titrate\ (\mathrm{FeCl3})\ \ x\ volume\ of\ sample}{Sample\ weight}$$

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2.3.3.4 Determination of oxalate

The permanganate titration method described by [23]. A measured weight of the sample was suspended in 100 ml of distilled water and 5ml of 6M HCl was added. The mixture was digested by heating at 100 ^{o}C for an hour. It was cooled and filtered. Then the pH was adjusted by adding 2 drops of methyl red indicator followed by drop wise addition of concentrated aqueous ammonia solution (NH_40H) until a faint yellow colouration was obtained at pH between 4 to 4.5. The mixture was heated to 90^{o}C in a water bath, cooled andfiltered (to remove ferrous ion precipitates). The filtrate was again heated at 90 ^{o}C and 10 ml of 5% $CaCl_2$ solution was added with constant steering. It was allowed to cool and then allowed to stay overnight in the refrigerator (5^{o}C). The mixture was centrifuged at 3 xg for 6 minutes. The supernatant was decanted and the precipitate was dissolved in 10 ml of 20% H_2SO_4. The solution was made up to 100 ml with distilled water and was titrated against 0.05 $KMnO_4$ solutions to a faint pink colour which persisted for 30 sec. The oxalate content was

given by the relationship that 1ml of 0.05m.

KMnO4 solution = 0.00225g oxalate

Calculation of oxalate content:

$$Oxalate\ (\frac{mg}{kg})\ = \frac{100\ \ x\ titre\ x\ 0.00225}{Sample\ weight}$$

2.3.4 Statistical Analysis

Data obtained from the experiment was subjected to randomized block design and statistical analysis using SPSS version 20 and mini tab version 16. Where the statistical analysis showed significant differences, the means were separated using the Duncan Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Effect of Processing Techniques on the Proximate Composition of African YamBean

The results of the effect of processing techniques on the proximate composition of African yam bean are presented in Table 1. The moisture content were 9.50, 10.50, 4.20, 11.97 and 11.40% respectively of control, boiled, roasted, autoclaved and de-hulled samples. The results showed that roasted sample had the lowest moisture content while autoclaved and de-hulled samples had the highest moisture content. Roasted sample is most likely to have a stable shelf-life, whereas autoclaved and de-hulled samples are most likely to be susceptible to biochemical and microbiological degradation. The crude protein content were 21.93, 22.00, 23.39, 22.19 and 23.38% respectively of control, boiled, roasted, autoclaved and de-hulled samples. The results showed that all samples had significant high protein content, with the roasted and de-hulled samples having the highest. The significant high protein content observed in the de-hulled sample could be attributed to the removal of the hull which contains most of the anti-nutritional compounds and it is comparable with the work of [24] where protein content in de-hulled soybean was observed as 25.07%. The crude fat were 1.04, 1.85, 1.30, 1.05 and 1.13% respectively of control, boiled, roasted, autoclaved and de-hulled samples. The low crude fat recorded in the processed samples show that African yam bean would be less prone to rancidity. The ash content were 5.97, 5.90, 7.64, 4.99 and 1.99% respectively of control, boiled, roasted, autoclaved and de-hulled samples. Roasted sample was observed to have the highest ash content with the lowest recorded in de-hulled. The lowest ash content observed in de-hulled sample may be due to the removal of the seed coat during de-hulling where most of the ash is found, however the high ash content recorded in control, boiled, roasted and autoclaved is an indication of high mineral composition in African yam bean.

Table 1. Proximate Composition of processed African yam bean

Sample	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Total Ash (%)	Carbohydrate (%)
Control	$9.50^{c} \pm 0.13$	$21.93^{c} \pm 0.13$	$1.04^{d} \pm 0.06$	$5.97^{b} \pm 0.04$	$4.83^{b} \pm 0.14$	$56.73^{c} \pm 0.15$
Boiled	$10.50^{b} \pm 0.12$	$22.00^{b} \pm 0.07$	$1.85^{a} \pm 0.23$	$5.90^{b} \pm 0.07$	$3.40^{d} \pm 0.08$	$56.62^{c} \pm 0.05$
Roasted	$4.20^{d} \pm 0.15$	$23.39^{a} \pm 0.06$	$1.30^{b} \pm 0.14$	$7.64^{a} \pm 0.13$	$5.69^{a} \pm 0.11$	$67.78^{a} \pm 0.16$
Autoclaved	$11.97^{a} \pm 0.58$	$22.19^{b} \pm 0.24$	$1.05^{d} \pm 0.17$	$4.99^{c} \pm 0.21$	$4.18^{c} \pm 0.05$	$55.60^{d} \pm 0.08$
De-hulled	$11.40^{a} \pm 0.20$	$23.38^{a} \pm 0.07$	$1.13^{c} \pm 0.06$	$1.99^{d} \pm 0.09$	$1.28^{e} \pm 0.17$	$60.82^{b} \pm 0.05$

Values are means of triplicates
Values along the same column followed by different superscripts are significantly different ($p<0.05$)

3.2 Effect of Processing Techniques on the Functional properties of African Yam Bean

The results of the influence of processing techniques on the functional properties of African Yam Bean are presented in Table 2. The water absorption capacity were 186, 240, 220, 220 and 250%(g/g), respectively of the control, boiled, roasted, autoclaved and de-hulled samples. Oil absorption capacity were 100, 120, 110, 128 and 120%(g/g); least gelation capacity were 14, 16, 16, 14 and 14 g; foaming stability were 4.23, 0.38, 0.56, 1.39 and 2.20% while solubility were 2.30, 1.10, 1.20, 1.60 and 1.30% (g/g).The functional properties of African yam bean revealed that processing had no significant effect on oil absorption capacity, emulsion capacity, foaming capacity, least gelation capacity and foaming stability of raw and processed African yam bean, while bulk density and water absorption capacity were significantly affected by processing techniques. The water absorption capacity in the raw and processed African yam bean ranged from 186 to 250%. The values recorded for roasted, boiled, autoclaved and de-hulled samples are not significantly different. The values recorded in this study are comparable to the previous report by [25]. There were significant reduction in both loose bulk density and packed bulk density as influenced by the processing procedures.

3.3 Effect of Processing Techniques on the Anti-nutritional properties of African Yam Bean

The results of the influence of processing techniques on the anti-nutritional properties of African Yam Bean are presented in Table 3. The results showed that phytate were 0.390, 0.419, 0.254, 0.327 and 0.346 mg/kg; oxalate were 2255, 1485, 1100, 990 and 1430 mg/kg; tannin were 737.50, 550.00, 2300.00, 625.00 and 187.50 mg/kg; trypsin inhibitor were 105, 45, 220, 60 and 30 mg/kg, respectively of the control, boiled, roasted, autoclaved and de-hulled samples. The results showed roasted African yam bean had the lowest phytate content, while oxalate significantly reduced in boiled, roasted, autoclaved and de-hulled African yam beans with the autoclaved having the lowest. The results further showed that de-hulled had the lowest tannin content and trypsin inhibitor. The reduction observed in the anti-nutritional properties of the processed African yam bean could be attributed as a significant effect of boiling, roasting, autoclaving and de-hulling.

Table 2. Functional properties of processed African yam bean

Sample	Loose bulk density (g/cm^3)	Packed bulk density (g/cm^3)	Water absorption capacity % (g/g)	Oil absorption capacity % (g/g)	Least gelation capacity (g/cm^3)	Emulsion capacity (g/cm^3)	Foaming capacity (%)	Foaming Stability (%)	Solubility (%)
Control	0.636^{a}±0.13	0.826^{a}±0.10	186^{d}±0.07	100^{d}±0.09	14.00^{b}±0.23	5.90^{b}±0.08	15.49^{a}±0.21	4.23^{a}±0.06	2.30^{a}±0.09
Boiled	0.591^{c}±0.05	0.615^{d}±0.04	240^{b}±0.05	120^{b}±0.14	16.00^{a}±0.17	2.60^{d}±0.05	4.00^{e}±0.06	0.38^{e}±0.15	1.10^{e}±0.15
Roasted	0.636^{a}±0.14	0.800^{b}±0.13	220^{c}±0.05	110^{c}±0.20	16.00^{a}±0.19	2.10^{e}±0.15	2.41^{d}±0.14	0.56^{d}±0.04	1.20^{d}±0.18
Autoclaved	0.458^{d}±0.08	0.500^{e}±0.09	220^{c}±0.11	128^{a}±0.09	14.00^{b}±0.23	3.20^{c}±0.20	12.50^{b}±0.08	1.39^{c}±0.08	1.60^{b}±0.14
De-hulled	0.615^{b}±0.06	0.653^{c}±0.06	250^{a}±0.16	120^{b}±0.18	14.00^{b}±0.18	6.80^{a}±0.21	9.80^{c}±0.16	2.20^{b}±0.09	1.30^{c}±0.10

Values are means of triplicates
Values along the same column followed by different superscripts are significantly different ($p<0.05$)

Table 3. Anti-nutritional properties of processed African yam bean

Sample	Phytate (mg/kg)	Oxalate (mg/kg)	Tannin (mg/kg)	Trypsin (mg/kg)
Control	0.390^{b}±0.10	2255.00^{a}±0.12	737.50^{b}±0.10	105.00^{b}±0.16
Boiled	0.419^{a}±0.08	1485.00^{b}±0.08	550.00^{d}±0.07	45.00^{d}±0.21
Roasted	0.254^{e}±0.15	1100.00^{d}±0.21	2300.00^{a}±0.12	220.00^{a}±0.12
Autoclaved	0.327^{d}±0.09	990.00^{e}±0.18	625.00^{c}±0.24	60.00^{c}±0.34
De-hulled	0.346^{c}±0.05	1430.00^{c}±0.16	187.50^{e}±0.35	30.00^{e}±0.15

Values are means of triplicates
Values along the same column followed by different superscripts are significantly different ($p<0.05$)

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4. CONCLUSION.

The research has unravelled the influence of processing techniques on the anti-nutritional, functional and proximate properties of African yam bean. The research revealed that roasted and autoclaved African yam beans had the highest crude protein of 23.39 and 23.38%, respectively while the loose bulk density and least gelation capacity of 0.636and 16.00 g/cm^3,respectively was higher in roasted African yam bean; foaming capacity and emulsion capacity of 2.41 and 2.10% was however observed to be respectively lower. The results of the anti-nutritional properties further revealed that roasted African yam beans had the lowest content of phytate and oxalate while the significant high content of tannin and trypsin was also observed.

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