# Proximate, Anti-Nutritional Factors and Functional Properties of Processed African Yam Bean (*Sphenostylis Stenocarpa*) Residues

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***Abstract***
*The study evaluated the proximate, anti-nutritional factors and functional properties of processed African yam bean residues. African yam bean seeds were processed using different methods - cracked and boiled for 60 min; sprouted for 72 h; toasted at 170 ℃ for 30 min; soaked for 12 h and then for 30 min. The seeds were milled and passed through a 250 µm mesh size sieve and the coarse particles were designated as the residue. Unprocessed African yam bean residue was used as the control. The proximate, anti-nutritional factors and functional properties of the residues were evaluated using standard methods of analysis. The results of the proximate composition of the residues revealed that processing affected the moisture, ash, crude protein, crude fibre and carbohydrate contents of the African yam bean residues. The fat content of the residues was not affected by processing. The sprouted African yam bean residue (SAR) had the highest contents of ash and crude protein, the toasted sample (TAR) had the highest contents of fat and fibre, the soaked and boiled residue (SBR) had the highest carbohydrate content while the unprocessed residue (UAR) had the highest moisture content. There were significant reductions in the oxalate, alkaloid, phytate and tannin contents of the processed African yam bean residues. The results of functional properties of the residues revealed that the bulk density and water absorption capacity increased with processing, oil absorption capacity did not vary significantly except for the sprouted residue that was slightly higher while dispersibility reduced with processing. The study revealed that sprouting improved the ash and protein contents of the residue while soaking prior to boiling was more effective in reducing the anti-nutritional factors. The inclusion of African yam bean residues in food formulations should be explored.*

***Keywords:*** *African yam bean, food processing, residues, proximate composition, anti-nutritional factors, functional properties*

## 1.0 Introduction

African yam bean is a leguminous crop belonging to the family *Fabaceae* and genus *Sphenostylis* (Olaniyi et al., 2019). The legume is grown in the tropics for its seeds and tubers. It has several local names such as "odudu", "akidi", "ijiriji" "uzoaki" and "azama" in the Southeastern part of Nigeria (Nnamani et al., 2017). African yam bean is an underutilized legume with nutritional potentials that could improve protein deficiency in human nutrition due to its high nutritional values (Nnamani et al., 2017). African yam bean like most legumes, contains anti-nutritional factors which could be reduced with processing.

Food processing is the transformation of food items from the state in which they are harvested to a consumable form (Weaver et al., 2014). Food processing improves the quality and safety of food products for human consumption, increases shelf-life and ensures availability of a variety of food products in and out of season (Michel et al., 2024). Food processing involves mechanical, chemical and thermal methods that modify the food matrix and also affect the chemical structure and physiological accessibility of nutrients (Anih et al., 2025). Some of these processing techniques include dehulling, boiling or cooking, germination, roasting, toasting, fermentation, radiation, extrusion cooking as well as various chemicals and enzymes (Arif et al., 2012). These techniques are often used to reduce the anti-nutritional factors in foods particularly legumes to a tolerable limit thereby making them safe for human consumption (Sobuola, et al., 2012; Popova and Mihaylova, 2019). Sometimes more than one technique is utilized to effectively reduce the anti-nutritional factors in legumes (El-Hady and Habiba 2003). Local food processors often soak legumes in water prior to cooking to reduce cooking time (Taiwo et al., 1997).

Processing African yam bean into flour will reduce the long cooking time and increase the utilization of the legume. However, the process of producing flour involves sieving which separates the endosperm from the germ and bran. The bran and germ which are by-products are often referred to as residue. Heshe et al., (2016) noted that the processes involved in flour production reduces the nutrient content of the flour and concentrates them in the residue. However, the residue obtained after flour extraction is often discarded as waste product. Ravindran & Jaiswal, (2016) opined that most food processing operations generates large quantities of residues which end up as waste annually. Residues are one of the by-products of food processing. Food processing by-products have economic and environmental consequences. Their accumulation has negative impact on the environment due to the issues associated with waste disposal and dumping (Dey *et al*., 2021). The situation is worse in Sub-Saharan Africa due to the high (more than 20%) production of food waste and the poor waste disposal methods (Food and Agricultural Organization (FAO, 2015). In Nigeria, most of the by-products of food processing that end up as waste in dumpsites are burnt thus, generating a lot carbon dioxide and increasing greenhouse gas emission. The Food and Agricultural Organization (2015) reported that food processing by-products are the second highest cause of greenhouse gas emissions. Most of the greenhouse gases originate from landfills of decaying foods; on-farm agriculture emissions and heat generated in the food manufacturing processes (Lau et al., 2021). Also, improper management of the waste generated from by-products of food processing could increase the spread of infectious diseases (OECD-FAO, 2023). The by-products generated during processing of legumes can exceed 25% of the total biomass (Tassoni et al., 2020). By-products from legumes are the pods, seed coat, husk, hull, flour fractions, waste water and okara the residue generated after milk extraction from soybean and other legumes (Lian et al., 2020; Nartea et al., 2023). Some of these by-products have been identified as good sources of nutrients (Adhikari et al., 2018; Guan et al., 2018). Torres-Leon et al., (2018) noted that by-products of food processing contain some amounts of proteins, lipids,

starch, micronutrients, bioactive compounds and dietary fibre. The by-products from legumes contain high amounts of polyphenols, protein, dietary fibre and other important nutritional components (Sun et al., 2020). The seed coats of most legumes contain bioactive compounds such as phytosterols, phytates, saponins, polyphenols, and lectins (Saini et al., 2019). Tapal & Purnima (2013) reported that the seed coat and broken seeds of pigeon pea are a rich source of protein and has a high gelling ability that could be used as a functional food material. Thus, African yam bean residue might also contain valuable nutrients which could be used as value-added ingredient in food products for human consumption.

The nutrient composition of a food material is important when considering it as a food ingredient as it could affect the behaviour of the raw material as well as the finished product (Kumari and Sangeetha 2017; Awuchi et al., 2019). The nutrient composition of the food material depends partly on the methods of processing (Beleya et al., 2026). It also influences the functionality of a food material for food product development (Eke-Ejiofor et al., 2022). Evaluating the nutrient composition of African yam bean residue would provide a basis for predicting the suitability and safety of the residue as an ingredient in food product development. Thus, this study aimed at assessing the proximate, antinutritional factors and functional properties of processed and unprocessed African yam bean residues.

## 2.0 Materials and Methods

African yam bean seeds (cream coloured variety) were purchased from a local market (Orie-ugba) in Umuahia, Abia State. All the chemicals used were of analytical grade and were obtained from the Laboratory of the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State.

### 2.1 Processing of African yam bean residue

The method described by Abioye et al. (2018) was modified and four processing methods were used to obtain African yam bean residue. These processing methods are cracked and boiled, sprouted, toasted and soaked and boiled. Unprocessed African yam bean residue was used as control.

**Cracked and boiled African yam bean residue:** African yam bean seeds were sorted, cracked with Corona hand grinder, boiled over gas cooker for one hour, allowed to cool and dehulled manually. The seeds were dried in an air oven at 60 °C for 12 hours, milled with an electric blender (Silver Crest SC 1589) and sieved through 250 µm mesh size sieve to obtain the residue.

**Sprouted African yam bean residue:** Sorted African yam bean seeds were soaked in cold water (1:5 w/v) for 12 hours, drained and evenly spread on a tray lined with moist cotton wool, covered with cotton wool and left for 72 hours to sprout. The sprouted seeds were dehulled manually, dried at 60 °C for 12 hours in an air oven, milled using a Silver Crest blender (SC 1589) and sieved with a 250 µm mesh size sieve to obtain the residue.

**Toasted African yam bean residue:** African yam bean seeds were sorted and toasted in an electric oven at 170 °C 30 minutes. The toasted seeds were cracked with Corona hand grinder, winnowed to remove the husk/chaff, milled using a Silver Crest blender (SC 1589) and passed through a 250 µm mesh size sieve to obtain the residue.

**Soaked and boiled African yam bean residue:** African yam bean seeds were sorted and soaked in water (1:5 w/v) for 12 hours after which the seeds were boiled for 30 minutes, allowed to cool and dehulled manually. The dehulled seeds were dried in an air oven at 60 °C for 12 hours, milled with a blender (Silver Crest blender SC 1589) and sieved using a 250 µm mesh size sieve to obtain the residue.

**Unprocessed African yam bean residue:** African yam bean seeds were washed in tap water, dried at 60 °C for one hour in an air oven, cracked using a Corona hand grinder, winnowed to remove the chaff, milled with a Silver Crest blender (SC 1589) and sieved with 250 µm mesh size sieve to obtain the residue.

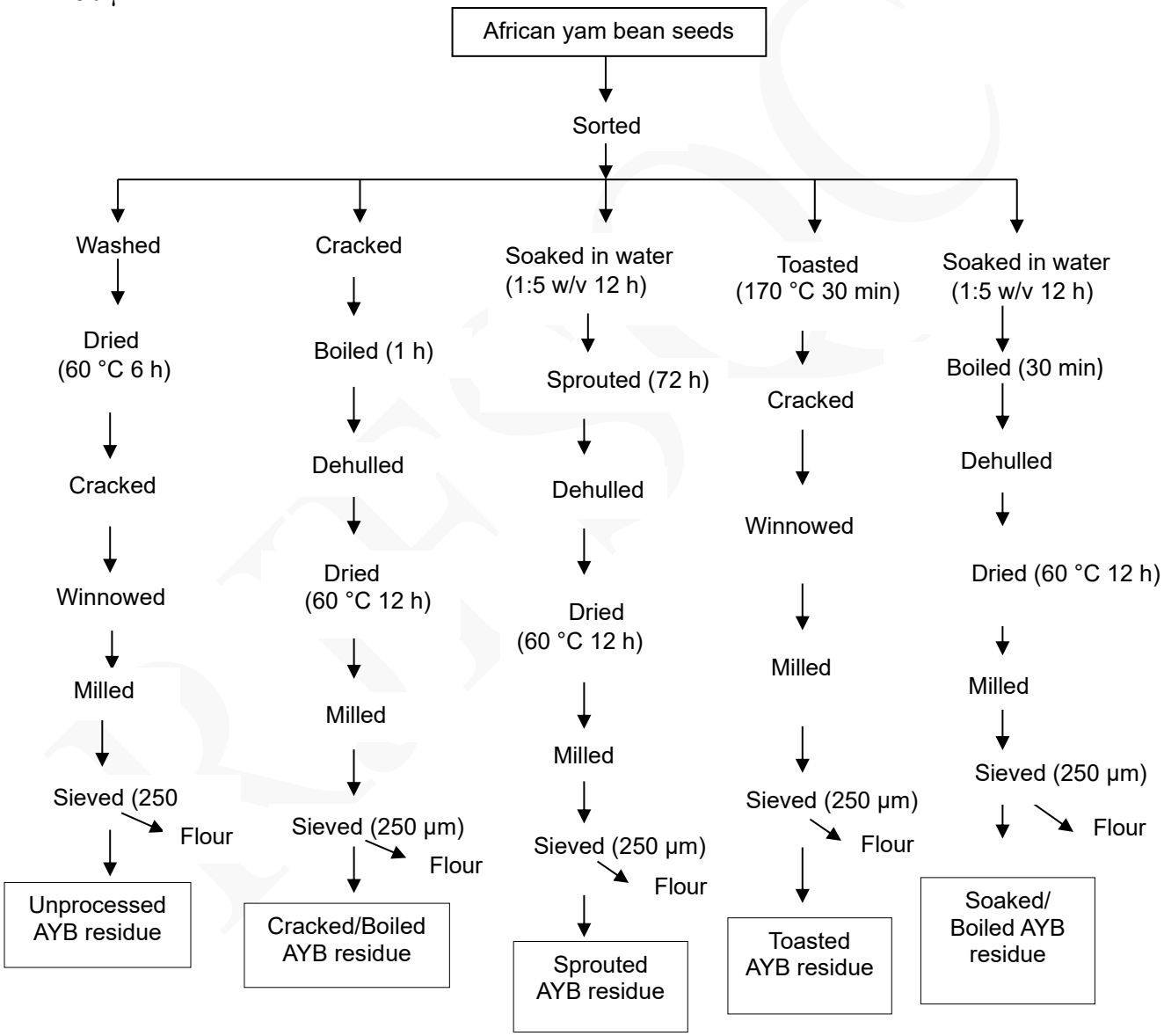



**Figure 1: Processing of African yam bean residue**

## 2.2 Determination of proximate composition of African yam bean residues

Moisture, ash, crude protein, crude fat and crude fibre contents of the African yam bean flour were determined according to the methods described by the Association of Official Analytical Chemists AOAC (2012).

**Moisture content:** Moisture content was determined using the air oven drying method. Moisture can was weighed and 2 g of the sample (2 g) was weighed into the moisture can and the weight recorded. The sample was dried in a hot air circulating oven (DHG 9140A) at 105 °C for 3 hours and transferred into a desiccator to cool for an hour and weighed until a constant weight was obtained.

$$\% \text{ Moisture} = \frac{W3 - W1}{W2 - W1} \text{ x } 100$$

Where, $W_1$ = weight of moisture can
$W_2$ = weight of moisture can and sample before drying
$W_3$ = weight of moisture can and sample after drying

**Ash content:** The sample (2 g) was weighed into a clean crucible and reweighed. The crucible with its content was placed in a muffle furnace (SXL -1002, China) chamber at 550 °C for 3 h. The crucible was removed from the furnace, cooled in desiccators and allowed to cool at room temperature and reweighed.

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} \text{ x } 100$$

Where, $W_1$ = weight of crucible
$W_2$ = weight of crucible and sample before ashing
$W_3$ = weight of crucible and sample after ashing

**Crude protein content:** This was determined using the micro-Kjeldahl method. The sample (1 g) was weighed into a digestion flask, two tablets of Kjedahl catalyst (each containing 1 g $Na_3$ SO4 + 0.05 g selenium) and 25 ml sulphuric acid ($H_2SO_4$) were added and digested by heating at 420 °C for 30 minutes in a fume cupboard. The digest was cooled, transferred into 100 ml flask and made up to the mark with distilled water. In a100 ml conical flask, 5 ml boric acid indicator was added as well as 10 ml of the digest and 10 ml of 60 % sodium hydroxide (NaOH) solution. The solution was titrated against 0.01 N hydrochloric acid. A blank was also prepared without the sample. The nitrogen content was calculated and the value was used to calculated the protein content.

$$\% \text{ Nitrogen} = \frac{VS - Vb \text{ x normality of acid x } 0.014}{W} \text{ x } 100$$

$$\% \text{ Crude protein} = \text{Nitrogen x conversion factor } (6.25)$$

Where, Vs = volume of acid used to titrate sample
Vb = volume of acid used to titrate blank
W = weight of sample

**Crude fat content:** This was determined using the soxhlet extraction method. The sample (2 g) was weighed and put in a thimble. The thimble was placed in boiling flask with 100 ml of n-hexane added and allowed to reflux for 6 hours at 60 °C. The extract was dried in a hot-air oven at 100°C for 30 minutes for the solvent to evaporate and then cooled in a desiccator and weighed.

$$\% \text{ Crude fat} = \frac{W4 - W3}{W2 - W1} \text{ x100}$$

Where, $W_1$ = weight of thimble
$W_2$ = weight of thimble and sample
$W_3$ = weight of flask
$W_4$ = weight of flask and residual oil

**Crude fibre content:** The sample (2 g) was weighed, extracted with n-hexane and transferred into a flask containing 100ml of 1.25 % of sulphuric acid ($H_2SO_4$), placed on a heating mantle and boiled for 30 minutes. The content was filtered; the residue was washed with distilled water and transferred to a beaker containing 1.25 % of sodium hydroxide (NaOH) and boiled for 30 minutes. The content was filtered again, washed with distilled water and the residue dried in a hot air oven at 130°C for 30 minutes, cooled in the desiccator, weighed and incinerated at 550°C for 3 hours then cooled and reweighed.

$$\% \text{ Crude fibre} = \frac{W2 - W3}{W2 - W1} \text{ x } 100$$

Where, $W_1$ = weight of sample
$W_2$ = weight of sample and dish after drying
$W_3$ = weight of sample and dish after incinerated

**Carbohydrate content**: The carbohydrate content was calculated by difference using the formula below:
% Carbohydrate = 100 – % (Moisture + Ash + Crude protein + crude Fat + Crude fibre)

### 2.3 Determination of Anti-nutritional factors of African yam bean residue

The anti-nutritional factors – oxalate, alkaloid phytate and tannin were determined as described by Nwosu (2013).

**Oxalate:** The samples (2 g each) were weighed, extracted thrice at 50 °C, stirred for 1hour with 20 ml of 0.3 M HCl. The extract was diluted to 100 ml with distilled water and used for total oxalate estimation by pipetting 5 ml of the extract which was made alkaline with 1ml of 5 M ammonium hydroxide. Phenolphthalein (3 drops) were added to the extract and acetic acid added in drops. About 1 ml of 5% CaCl (aq) was added to the mixture and allowed to stand for 2 hours after which it was centrifuged at 3,000 rpm for 15 min. The supernatants were discarded and the precipitates washed three times with hot water, thoroughly mixed and centrifuged each time. In the test tube, 2 ml of 3 M $H_2S0_4$ was added, the precipitate dissolved in water bath at 75 °C and then titrated with freshly prepared 0.01M $KMnO_4$ at room temperature until the first pink colour appeared throughout the solution and titration continued until the pink colour persisted.

$$\% \text{ Oxalate} = \frac{Vt}{Ws \text{ x } Vme \text{ x Titre}} \text{ x } 100$$

Vt = Total volume of Titre = 100 ml
Ws = Weight of sample
Vme = Volume – mass equivalent (i.e.1$cm^3$ of 0.05M $KMnO_4$ is equivalent to 0.00225g anhydrous oxalic acid)

**Alkaloid:** The sample (5 g) was weighed and dispersed in 100ml of 10% acetic acid solution in ethanol. The mixture was shaked properly; allowed to stand for 4 hours at room temperature and filtered through Whatman No. 42 filter paper. The filtrate was evaporated to a quarter of its original volume; concentrated $NH_3OH$ was added drop wise to precipitate the alkaloid and the precipitate filtered and dried in the oven at 60 °C for 30 minutes and reweighed after cooling in a desiccator.

$$\% \text{ Alkaloid} = \frac{W2 - W1}{W} X100$$

W = weight of sample
W1 =weight of empty filter paper
W2 = weight of paper plus precipitate

**Phytate:** The sample (2 g) was weighed into a test tube; 10 ml of distilled water was added and the sample extracted using 2 ml of 0.2 M HCl (aq). About 0.5 ml of the extract was pipetted into a test tube fitted with glass stopper and 1 ml of ferric solution was added, covered with stopper and heated in a boiling water bath for 30 min. The tube remained covered with the stopper for the first 15min; then the test tube cooled in ice water for 15min and allowed to adjust to room temperature. The content of the test tube was mixed very well and centrifuged at 3,000 rpm for 30 min. About 1ml of the supernatant was transferred into another test tube and about 1.5ml of 2,2 bipyridine solution was added and the absorbance measured at 420 nm against distilled water.

$$\% \text{ Phytate} = \frac{Au}{As} X C x \frac{100}{w} x \frac{Vf}{Va}$$

Au = absorbance of sample
As = absorbance of standard solution
C= concentration of standard solution
W = weight of sample
Vf = total volume of extract
Va = volume of extract analyzed

**Tannin:** The sample (5 g) was put inside a volumetric flask and 50 ml of distilled water was added. The mixture was shaken for 30 minutes at room temperature and filtered to obtain the extract. A standard tannic acid solution was prepared; 2 ml of the standard solution and equal volume of distilled water were dispersed into a separate 50 ml volumetric flasks to serve as a standard and reagent blank respectively. Then 2ml of the sample was put in a flask, mixed with 35 ml of distilled water and 1ml of the Folin Denis reagent was added followed by 2.5ml of saturated $Na_2CO_3$ solution. The mixture was diluted to the 50 ml mark with distilled water and incubated for 90 minutes at room temperature. The absorbance of sample and blank was measured at 250 nm in a spectrophotometer.

$$\% \text{ Tannin} = \frac{Au}{As} X C x \frac{100}{w} x \frac{Vf}{Va}$$

Au = absorbance of sample
As = absorbance of standard solution
C= concentration of standard solution
W = weight of sample
Vf = total volume of extract
Va = volume of extract analyzed

### 2.4 Determination of functional properties of African yam bean residue

The bulk density, water and oil absorption capacities and dispersibility of the flour samples were determined by the methods of Onwuka (2018).

**Bulk density:** A graduated 10 ml measuring cylinder was weighed; the cylinder was filled with the sample, and the bottom was tapped gently on the laboratory bench several times until there was no further diminution of the sample at the 10 ml mark.

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

**Water and oil absorption capacities:** The sample (1 g) was weighed into a graduated centrifuge tube. A waring whirl mixer was used to mix thoroughly for 30 seconds after adding 10 ml of distilled water or oil. The mixture was allowed to stand at room temperature for 30 minutes and then centrifuged at 5000 rpm for 30 minutes. The volume of free water or oil (the supernatant) was read directly from the graduated centrifuge tube.

$$\text{Water or oil absorption capaciy} = \text{Volume of water or oil absorbed x density of water or oil}$$

**Dispersibility:** The sample (10 g) was weighed into a 150 ml measuring cylinder, and 100 ml of distilled water was added, stirred vigorously and allowed to settle for 3 hours. The volume of settled particles was recorded and subtracted from 100 to give a difference that is taken as percentage dispersibility.

$$\text{Dispersibility } (\%) = 100 - \text{Volume of settled pticles}$$

## 3.0 Results and Discussion

### 3.1 Proximate composition of African yam bean residue

The proximate composition of the African yam bean residue presented in Table 1 showed that the moisture content of the samples differed significantly ($p < 0.05$) and ranged from 8.87 % in toasted (TAR) sample to 11.04 % in the unprocessed (UAR) sample. The toasted (TAR) and the soaked and boiled (SBR) samples had the least moisture contents of 8.87 % and 9.85 % respectively. These samples would have longer shelf life due to their low moisture contents. Nwajagu et al., (2021), reported significant reduction in moisture content of roasted ox-eyed bean flour. Beleya et al., (2026) reported no significant difference in the moisture content of processed and unprocessed African yam bean flour. The ash content of a food material gives an indication of the minerals present in the food material (Beleya and Eke-Ejiofor, 2020). The ash content of the residues varied significantly ($p < 0.05$) and ranged from 1.35 % in sample CBR to 3.09 % in sample TAR. Residues obtained from the cracked and boiled and the soaked and boiled African yam bean seeds had the least ash contents of 1.35 % and 1.90 % respectively. The reduction in ash contents of these samples could be due to cracking and soaking which eased the leaching of the minerals in the boiling water thus, resulting in the low ash contents. Beleya et al., (2026) reported low ash contents in African yam bean flour samples which were cracked and soaked prior to boiling.

Processing had significant effect on the crude protein content of the African yam bean residues as all the processed samples had higher protein content than the unprocessed (control) sample. The

crude protein content of the residue increased significantly from 22.53% in sample UAR (unprocessed) to 24.72% in sample SAR (sprouted). Previous studies have reported that processing increases protein content of legumes (Anya and Ozung 2019; Keyata et al., 2018). The protein content of the residues are higher than the values reported by Beleya et al (2026) for processed and unprocessed African yam bean flour. This corroborates the findings of Sobota et al (2020) that by-products and wastes from food processing are good sources of protein and other functional compounds which can be used for the development of functional foods.

There was no significant ($p > 0.05$) difference in the fat content of the African yam bean residues. The fat content of the residues except sample SBR were lower than the range of 1.79 % to 3.78 % reported for processed and unprocessed African yam bean flour by Beleya et al (2026). Zarzycki et al., (2022) noted that most food residues except those from oil rich legumes have low fat contents but high in protein and fiber contents. The lower fat content of the residues suggests they would not substantially increase the fat content of food products when used in food formulations. Thus, African yam bean residues could be useful ingredients when formulating diets for individuals requiring reduced fat diet. The crude fibre content of the African yam bean residues varied significantly and ranged from 4.59 % in sample the SAR (sprouted residue) to 5.97 % in sample TAR (toasted residue). These values are higher than the range of 1.49 to 4.89 % reported by Beleya et al (2026) for fibre content of processed and unprocessed African yam bean flour. This indicates that the residues contain more fibre compared to the flour. This agrees with previous findings that reported high crude fibre content in food residues (Yusuf et al., 2022; Zarzycki et al., 2022). Anya and Ozung (2019) reported fibre contents of 7.00 %, 5.92 % and 5.50% for raw, boiled and toasted African yam bean seeds respectively. There were significant differences in the carbohydrate content of the residues which were between 55.21 % and 59.09 %. Sample CBR (57.59 %) and SBR (59.09 %) had higher carbohydrate contents than other processed samples. This could partly be due to the low content of ash and protein in these samples since carbohydrate was calculated by difference. However, El-Gohery (2021) also reported higher carbohydrate contents of 62.63 % in soaked and 63.89 % in cooked lima beans compared to 60.78 % in the raw sample. The sprouted residue (SAR) had the least (55.21 %) carbohydrate content. During sprouting, carbohydrates are used as a source of energy for embryonic growth resulting in the reduced carbohydrate content of germinated seeds (Maldonado-Alvarado et al., 2023). This may have contributed to the low carbohydrate content of the sprouted African yam bean residue (SAR). Previous studies have reported reduction in carbohydrate content of sprouted cereals and legumes (Chauhan et al., 2022; Maldonado-Alvarado et al., 2023).

**Table 1: Proximate composition of African yam bean residue (%)**

| Samples | Moisture | Ash | Crude Protein | Fat | Crude Fibre | Carbohydrate |
|---|---|---|---|---|---|---|
| UAR | $11.04^{a} \pm 0.79$ | $2.90^{a} \pm 0.56$ | $22.53^{c} \pm 0.31$ | $1.60^{a} \pm 0.28$ | $4.69^{b} \pm 0.41$ | $57.24^{ab} \pm 0.23$ |
| CBR | $10.67^{a} \pm 0.35$ | $1.35^{b} \pm 0.35$ | $23.41^{bc} \pm 0.31$ | $1.79^{a} \pm 0.01$ | $5.18^{ab} \pm 0.14$ | $57.59^{ab} \pm 0.01$ |
| SAR | $10.60^{a} \pm 0.84$ | $3.14^{a} \pm 0.05$ | $24.72^{a} \pm 0.31$ | $1.73^{a} \pm 0.07$ | $4.59^{b} \pm 0.84$ | $55.21^{c} \pm 0.29$ |
| TAR | $8.87^{b} \pm 0.38$ | $3.09^{a} \pm 0.13$ | $23.84^{ab} \pm 0.92$ | $1.98^{a} \pm 0.01$ | $5.97^{a} \pm 0.24$ | $56.23^{bc} \pm 0.91$ |
| SBR | $9.85^{ab} \pm 0.07$ | $1.90^{b} \pm 0.00$ | $22.59^{bc} \pm 0.22$ | $1.62^{a} \pm 0.52$ | $4.98^{ab} \pm 0.01$ | $59.05^{a} \pm 0.38$ |

Values are means ± standard deviations of duplicate determinations. Means with different superscript on the same column are significantly different ($P < 0.05$).

Key: UAR = Unprocessed African yam bean residue (Control), CBR = Cracked and Boiled African yam bean residue, SAR = Sprouted African yam bean residue, TAR = Toasted African yam bean residue, SBR = Soaked and boiled African yam bean residue

### 3.2 Anti-nutritional factors of African yam bean residues

The result of the anti-nutritional factors in African yam bean residues showed that there are significant differences ($p<0.05$) in the oxalate content of the residues. The processed samples had significantly lower contents (0.21 to 0.39 %) of oxalate than the unprocessed sample (1.06 %). This suggests that the processing methods were effective in reducing the oxalate content of the processed African yam bean residues. The findings agree with that of Olaifa et al., (2022) who reported significant reduction in oxalate content of *Entada Africana* seeds from 3.56 mg in raw sample to 0.84 mg in processed sample. The oxalate contents of the residues were higher than the values of 0.0034 % to 0.0070 % reported by Ajibola and Olapade (2016) for processed African yam bean flour. The alkaloid content of the African yam bean residue varied significantly and reduced from 4.64 % in sample UAR (unprocessed AYB residue) to 2.65 % in sample SBR (soaked and boiled AYB residue). Sample SAR (sprouted AYB residue) did not differ significantly from sample UAR (unprocessed AYB residue). It could be deduced that sprouting is not very effective in reducing the alkaloid content of the residues. The findings corroborate that of Abeshu and Kefale (2017) who reported that soaking, fermenting and cooking were more effective in reducing alkaloid content of sweet and bitter lupin bean than germination.

There were significant differences ($p<0.05$) in the phytate content of the residues. Phytate decreased from 1.10 % in sample UAR to 0.52 % in sample SBR. The reduction in phytate content of the processed residues implies that processing methods were effective in reducing phytate in the residues. However, samples CBR and SBR which were cracked and soaked prior to boiling had lower contents of phytate than other processed samples. This corroborates the findings of Banti and Bajo (2020) who reported that combining two or more techniques are more effective in reducing anti-nutrients in legumes. Anaemene and Fadupin (2020) reported that germination in combination with 24 hours fermentation reduced more than 90% of the phytate in maize. The reduction in phytate content of the processed residues implies that the residues will not pose a health risk when used in food formulations for human consumption. Regular consumption of foods high in phytate could result to deficiencies of certain minerals since phytates bind minerals such as iron and zinc thereby reducing their bioavailability.

The tannin content of the African yam bean residue varied significantly ($p<0.05$) and reduced from 9.21 % in sample UAR (unprocessed) to 1.93 % in sample TAR (toasted). The reduction in tannin content of the processed African yam bean residue indicates that the different processing methods efficiently reduced tannins in the residue. Previous studies have reported the effectiveness of processing methods in reducing tannin in legumes. Gbenga-Fabusiwa (2021) reported reduction in tannin content of African yam bean seeds from 16.40 mg in unprocessed sample to 3.45 mg in the roasted sample. Adegboyega *et al*., (2020) also reported significant reduction in tannin content of different accensions of processed African yam bean seeds.

**Table 2: Anti-nutritional factors of African yam bean residue**

| Samples | Oxalate (%) | Alkaloid (%) | Phytate (%) | Tannin (%) |
|---|---|---|---|---|
| UAR | $1.06^{a} \pm 0.08$ | $4.64^{a} \pm 0.47$ | $1.10^{a} \pm 0.90$ | $9.21^{a} \pm 0.02$ |
| CBR | $0.23^{b} \pm 0.01$ | $3.74^{ab} \pm 0.06$ | $0.60^{bc} \pm 1.13$ | $2.70^{bc} \pm 0.05$ |
| SAR | $0.39^{b} \pm 0.09$ | $4.23^{a} \pm 0.05$ | $0.83^{ab} \pm 0.81$ | $2.78^{b} \pm 0.19$ |
| TAR | $0.38^{b} \pm 0.08$ | $4.09^{ab} \pm 0.27$ | $0.90^{a} \pm 0.07$ | $1.93^{d} \pm 0.10$ |
| SBR | $0.21^{b} \pm 0.01$ | $2.65^{b} \pm 1.62$ | $0.52^{c} \pm 0.00$ | $2.19^{cd} \pm 0.12$ |

Values are means ± standard deviations of duplicate determinations.
Means with different superscript on the same column are significantly different ($P < 0.05$).
Key: UAR = Unprocessed African yam bean residue (Control), CBR = Cracked and Boiled African yam bean residue, SAR = Sprouted African yam bean residue, TAR = Toasted African yam bean residue, SBR = Soaked and boiled African yam bean residue

### 3.3 Functional properties of African yam bean residue

The result of the functional properties of the African yam bean residue presented in Table 3 revealed that the bulk densities of the processed residues were higher than the of the unprocessed sample (UAR) except for sample SBR. The processed samples would require more packaging material due to their higher bulk density. The values obtained in this study are similar to the value of 0.89 g/ml reported by Olawumi et al., (2014) for soaked African yam bean flour.

The water absorption capacity of the residues increased with processing. The Toasted African yam bean residue (TAR) had the least (2.62 g/ml) water absorption capacity of all the processed samples. The higher fat content (1.98 %) of sample TAR may have contributed to its reduced water absorption ability. Water and oil are two liquids that cannot mix without an emulsifier and food materials with high amounts of oil tend to absorb less water. The cracked and boiled residue (CBR) had the highest water absorption capacity of 3.41 g/ml. The higher water absorption capacity of sample CBR suggests it would be suitable for incorporation into flour for bread making.

The oil absorption capacity of the residues differed significantly and ranged from 2.20 g/ml in sample SBR to 2.51 g/ml in sample SAR. The high oil absorption capacity of sample SBR suggest when incorporated into flours for bakery products would enhance the texture and retain flavour of the final product while serving as a source of fibre in the product. The oil absorption capacities of the residues are slightly higher than the values reported for processed African yam bean flour samples by Beleya et al (2026). The dispersibility of the residues varied significantly and reduced with processing ranging from 62.00 % in the toasted African yam bean residue (TAF) to 72.00 % in the unprocessed African yam bean residue (UAR). The sprouted African yam bean residue (SAR) had the highest (68.50 %) dispersibility of all the processed samples. The higher water absorption capacity of the sprouted African yam bean residue (SAR) may have contributed to its higher dispersibility. Food materials with high dispersibility are easier to reconstitute and have better consistency (Beleya et al., 2026). The higher dispersibility of the sprouted African yam bean residue (SAR) suggests it could be incorporated into flour as composite for bakery products. The values obtained in this study are lower than the values of 73.75% to 75.25 % reported for wheat/ African yam bean/acha flour blends by Adeyanju *et al*. (2021) but similar with the values of 65.00 % to 72.00 % reported for African yam bean flour by Beleya et al (2026).

**Table 3: Functional Properties of African yam bean residue**

| Samples | Bulk Density (g/ml) | Water Absorption Capacity (g/ml) | Oil Absorption Capacity (g/ml) | Dispersibility (%) |
|---|---|---|---|---|
| UAR | $0.81^{d}$ ±0.00 | $2.61^{e}$ ±0.01 | $2.25^{b}$±0.00 | $70.00^{a}$ ±0.00 |
| CBR | $0.89^{a}$±0.00 | $3.41^{a}$ ±0.01 | $2.22^{b}$±0.01 | $64.00^{d}$±0.00 |
| SAR | $0.86^{b}$±0.00 | $3.15^{b}$±0.00 | $2.51^{a}$±0.20 | $68.50^{b}$±0.70 |
| TAR | $0.83^{c}$±0.00 | $2.62^{d}$±0.01 | $2.22^{b}$±0.01 | $62.00^{e}$±0.00 |
| SBR | $0.81^{d}$±0.00 | $2.98^{c}$±0.00 | $2.20^{b}$±0.00 | $65.00^{c}$±0.00 |

Values are means ± standard deviations of duplicate determinations.
Means with different superscript on the same column are significantly different ($P< 0.05$).
Key: UAR = Unprocessed African yam bean residue (Control), CBR = Cracked and Boiled African yam bean residue, SAR = Sprouted African yam bean residue, TAR = Toasted African yam bean residue, SBR = Soaked and boiled African yam bean residue

## 4.0 Conclusion

The proximate, anti-nutritional and functional properties of processed African yam bean residues were evaluated. The processing methods utilized enhanced the proximate composition and functional properties and significantly reduced the anti-nutritional factors in the residues. Sprouting significantly increased the ash and protein contents of the residues, reduced the oxalate, phytate and tannin contents as well as increased the water and oil absorption capacities and dispersibility of the residues. The residues have potentials for use as functional ingredient in food formulations; particularly as composite with flours from cereals and tubers due to their high protein and fibre contents as well as their increased water and oil absorption capacities. The utilization of African yam bean residue as a functional ingredient in food product development is encouraged and should be explored.

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