EFFECT OF PROCESSING METHODS ON THE NUTRITIONAL AND ANTI-NUTRITIONAL PROPERTIES OF *Sphenostylis stenocarpa* (AFRICAN YAM BEAN) SEED

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ABSTRACT

The analysis of the raw and processed Sphenostylis stenocarpa seed was carried out for antinutritonal properties, mineral elements, heavy metal and proximate composition. The composition of Anti-nutritional factors was carried out using standard laboratory methods. Mineral composition was determined using Flame Photometer, while heavy metal composition was determined using the Atomic Absorption Spectrophotometer (AAS). The results of the analysis showed the composition of these properties (in raw, soaked and cooked samples respectively). For proximate composition, the samples were found to contain 9.06±0.77%, 9.60±0.02% and 16.41±0.49% moisture, respectively; 2.57±0.14%, 2.23±0.02% and 2.23±0.02% ash, respectively; 10.11±0.01%, 10.21±0.04% and 9.53±0.06% crude fibre, respectively; 25.17±0.01%, 24.25±0.49 and 20.13±0.02% crude protein respectively; 2.21±0.02%, 2.17±0.01% and 1.53±0.01% crude fat, respectively; 51.19±0.01%, 51.02±0.14% and 49.81±0.02% carbohydrate respectively. For Anti-nutritional factors, the samples were found to contain 8.08±0.014 mg/kg, 3.22±0.010 mg/kg and 2.42±0.010 mg/kg oxalate respectively; 28.08±0.010 mg/kg, 11.25±0.010 mg/kg and 5.44±0.010 mg/kg tannins respectively; 94.32±0.010 mg/kg, 49.86±0.010 mg/kg and 43.71±0.010 mg/kg cyanogenic glycosides, respectively; 9.26±0.010 mg/kg, 5.81±0.010 mg/kg and 2.00±0.010 mg/kg saponins respectively; 2.27±0.010 mg/kg, 1.71±0.010 mg/kg and 0.36±0.010 mg/kg phytate respectively; 0.22±0.010 mg/kg, 0.11±0.010 mg/kg and 0.02±0.010 mg/kg alkaloids respectively. The mineral elements and heavy metal compositions were found to be 126.60 ppm, 102.90 ppm and 98.40 ppm calcium, respectively; 98.20 ppm, 71.60 ppm and 65.40 ppm magnesium respectively; 29.50 ppm, 25.50 ppm and 21.30 ppm sodium respectively; 27.30 ppm, 21.90 ppm and 20.05 ppm potassium respectively; 9.50 ppm, 6.10 ppm and 5.80 ppm zinc respectively; 0.90 ppm, 0.40 ppm and 0.20 ppm lead, respectively; 0.85 ppm, 0.50 ppm and 0.13 ppm cobalt respectively; 2.02 ppm, 0.10 ppm and 0.03 ppm chromium respectively; 14.96 ppm, 11.30 ppm and 9.09 ppm iron, respectively. These results show that processing has remarkable impact on the nutritional and Anti-nutritional properties of S. Stenocarpa seed.

Keywords: *Sphenostylis stenocarpa*, Nutritional, Anti-nutritional, Processing, Toxicological.

INTRODUCTION

Legumes are important ingredients of a balanced human diet in many parts of the world owing to their high protein and starch contents. They have been consumed traditionally as whole seed or as ground floor after dehulling (Adebowale *et al.*, 2009). They have, however, been underutilized because of the presence of Anti-nutritional factors such as enzymes (which include trypsin, chymytrypsin and α-amylase), which negatively affect their nutritional value (especially beans) through direct and indirect reaction. They thus, inhibit protein and carbohydrate digestibility, induce pathological changes, inhibit a number of enzymes, and bind nutrients, thus, making them unavailable (Oberleas, 2000).

Sphenostylis stenocarpa belongs to the family *Fabaceae* and it is known by different names depending on where it is found. It is grown in Africa and other parts of the world (Klu *et al.*, 2001). It is grown both for its edible seeds and its tubers. The seeds of the plant are mostly used in

some regions, such as the Northern part of Nigeria. However, there is a cultural and regional preference for each; West Africa prefers the seed to tubers, while the tubers are highly cherished as food among East and Central Africans. Its exceptionally nutritious pulse has a very significant link with African socio-cultural life (Klu *et al.*, 2001).

The economic potentials of *Sphenostylis stenocarpa* are immense. Apart from the production of some major food substances, the values of proteins in both tubers and seeds are reported to be comparably higher than what could be obtained from most tuberous and leguminous crops (Klu *et al.*, 2001). The protein in its tuber is reported to be more than twice the protein in sweet potato and higher than those in yam and cassava (Ekpo, 2006). It is also reported to be so rich in some vital mineral elements such as potassium, phosphorus, magnesium, calcium, iron and zinc; but low in sodium and copper (AOAC, 2000).

The nutritional value of a plant is assessed by taking several properties of the plant into consideration. These properties include the proximate, mineral elements, vitamins and heavy metal composition. These components also known as nutrients (both macro and micro), supply nourishment to the body (Joshi, 2002), as they take part in various metabolic activities.

Anti-nutritional properties which include oxalates, phytate, cyanogenic glycosides, saponins, gossypol, tannins, flavonoids and antivitamins are chemicals evolved by plants for their own defence, among other biological functions and reduce the maximum utilization of nutrients especially proteins, vitamins and minerals, thus, preventing optimal exploitation of the nutrients present in a food and decreasing the nutritive value (Ugwu and Oranye, 2006).

Different processes have been used in processing *S. Stenocarpa* seed before consumption. Some of these methods include; parboiling, soaking in water and milling. These methods may affect the nutritional value of the seed and the composition of its Anti-nutritional factors. The aim of this study is therefore, to investigate the effect of different processing methods on the nutritional and toxicological components of *S. Stenocarpa* seed.

The objective of the study is to investigate the effect of these processes on: the proximate composition of the seed, the mineral elements and heavy metal composition of the seed; and the Anti-nutritional properties of the seed.

MATERIALS AND METHODS

Sample Collection, Identification and Preparation

The seed sample of *S. Stenocarpa* was collected from Ajaka, Igalamela-Odolu Local Government Area of Kogi State, Nigeria. It was identified in the Department of Science Laboratory Technology, Federal Polytechnic, Idah. It was then divided into three portions. The first portion was soaked in water for 72 hours before oven-drying. The second portion was cooked in water for about 4 hours and the third portion was milled raw.

Proximate Analysis

The moisture, ash, crude fat, crude fibre, crude protein and carbohydrate contents were determined following the methods described by AOAC (1990). Carbohydrate content was calculated by difference (100-(% ash + % moisture + % crude fat + % crude fibre + % crude protein) (Onwuka, 2005).

Mineral Composition

The mineral composition of the seed was determined by the method described by AOAC (2000) and AOAC (2010). The mineral elements determined were sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg). The composition of the mineral elements was calculated in parts per million.

Determination of Sodium Content

1.9 g of the sample was digested with 20 mL of acid mixture (650 mL of concentrated HNO_3 : 80 mL $HClO_4$:20 mL concentrated H_2SO_4). Aliquots of the dilute digest were analysed using Flame Photometer.

Determination of Potassium Content

Potassium stock solution of 100 ppm was prepared by dissolving 1.90 g of KCl in distilled water. It was diluted to 1 L. The digested sample was then analyzed using Flame Photometer.

Determination of Magnesium

10 mL of the sample (digest) was collected (using a pipette) into a volumetric flask and eriochrome black-T indicator was added to the mixture. This was then titrated with EDTA to blue colour. The magnesium content was calculated as:

$$\% \text{ magnesium} = \frac{\text{titre} \times 0.01M \times 40 \times 100}{1000 \times 2\text{ g} \times 10}$$

Determination of Calcium Content

10 mL of the sample (digest) was collected (using a pipette) into a volumetric flask and 25 mL distilled water was added. 25 mL KOH and a pinch of calcine indicator was added to the mixture and then titrated with 0.01M ethylenediaminetetraacetic acid (EDTA). The calcium content was calculated as:

$$\% \text{ calcium} = \frac{\text{titre} \times 0.01M \times 40 \times 100}{1000 \times 2g \times 10}$$

Heavy Metal Composition

The heavy metal composition of the seed was determined by the method described by AOAC (2000). The heavy metals determined were Lead (Pb), Cobalt (Co), Iron (Fe), Zinc (Zn) and Chromium (Cr). The composition of heavy metals was calculated in parts per million (ppm).

Determination of Lead Content

An AAS was calibrated with a slit width of 0.7 nm and at a wavelength of 283.3 nm. Then 5 mL of the digested sample was transferred into a 100 mL volumetric flask and diluted to the 100 mL mark. The prepared sample was then atomized and the absorbance was recorded. The concentration of lead was calculated as:

$Y = 0.45 X$ (mg/kg)

Where Y = absorbance

X = concentration

Determination of Cobalt Content

An AAS was calibrated with a wavelength of 400 nm and slit width of 1.5 nm. Then 5 mL of the digested sample was transferred into a 100 mL volumetric flask and diluted to the 100 mL mark. The prepared sample was then atomized and the absorbance was recorded. The cobalt content was calculated as:

$Y = 0.995 X$ (mg/kg)

Where Y = absorbance

X = concentration

Determination of Iron Content

An AAS was calibrated with a wavelength of 248.3 nm and slit width of 0.2 nm. Then 5 mL of the digested sample was transferred into a 100 mL volumetric flask and diluted to the 100 mL mark. The prepared sample was then atomized and the absorbance was recorded. The iron content was calculated as:

$Y = 0.166 X$ (mg/kg)

Where Y = absorbance

X = concentration

Determination of Zinc Content

An AAS was calibrated with a wavelength of 218 nm and slit width of 0.7 nm. Then 5 mL of the digested sample was transferred into a 100 mL volumetric flask and diluted to the 100 mL mark. The prepared sample was then atomized and the absorbance was recorded. The zinc content was calculated as:

$Y = 0.078 X$ (mg/kg)

Where Y = absorbance

X = concentration

Determination of Chromium Content

An AAS was calibrated with a wavelength of 630 nm and slit width of 2.3 nm. Then 5 mL of the digested sample was transferred into a 100 mL volumetric flask and diluted to the 100 mL mark. The prepared sample was then atomized and the absorbance was recorded. The zinc content was calculated as:

$Y = 0.186 X$ (mg/kg)

Where Y = absorbance

X = concentration

Determination of Antinutrients

The Anti-nutritional factors of the seed were determined by the method described by AOAC (2000). The Anti-nutritional factors determined were tannins, saponins, alkaloids, oxalates, phytates and flavonoids. The composition of the antinutrients was calculated in mg/kg.

Determination of Total Tannin Content

The total tannin content was determined by the method described by AOAC (2000). 0.1 mL of the sample was transferred into a 10 mL volumetric flask containing 7.5 mL of distilled water and 0.5 mL of phenol. 1 mL of 35% sodium carbonate solution was diluted to 10 mL using distilled water. The mixture was shaken vigorously and kept at room temperature for 30 minutes. A set of reference

standard solutions of gallic acid (20, 40, 60, 80 and 100 mg/mL) were prepared. The absorbances of the test and standard solutions were measured against the blank at 725 nm, using a UV/visible spectrophotometer. The tannin content was calculated and expressed in terms of mg/g of the extract. The formula below was used to calculate the tannin content:

$Y = 0.057X-0.071(R^2)$

Where Y = absorbance

X = concentration

R = correlation coefficient

Determination of Total Saponin Content

The total saponin content was determined by the method described by Makkar, *et al.* (2007). 0.5 g of the sample was added to 250 mL of vanillin solution (800 mg of vanillin in 10 mL of 99.5 % ethanol) in a volumetric flask. 2.5 mL of 72 % sulphuric acid was added and shaken vigorously. This solution was kept in a water bath at 60^{o}C for 10 minutes. It was then cooled in ice-cold water and the absorbance was read at 544 nm. The saponin content was calculated as:

$Y = 0.005X-0.0052 (R^2)$

Where Y = absorbance

X = concentration

R = correlation coefficient

Determination of Alkaloid Content

The total alkaloid content was determined by the method described by AOAC (2000). 50 mL of 20% acetic acid was added to 4 g of the sample in 250 mL beaker and covered to stand for 4 hours. The mixture was filtered and the volume was reduced to one quarter by heating in a water bath. Concentrated ammonium hydroxide was added to the filtrate drop-wise until precipitation was complete. The resulting mixture was allowed to settle and the precipitate was collected by filtration and weighed. The percentage of total alkaloid was calculated as:

$$\% \text{ alkaloid} = \frac{\text{Residual weight}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of Oxalate Content

The total oxalate content was determined using the method described by Fasset (1996). Extraction was done by adding 1 g of each sample into 10 mL of distilled water. These were allowed to stand for 3 hours after which each was filtered through a double layer of filter paper. 10, 20, 30, 40 and 50 ppm standard solutions of oxalic acid were prepared and their absorbances were read by the use of UV/visible spectrophotometer at 420 nm. The absorbance of the filtrate from each sample was also read. The oxalate content was calculated as:

Absorbance = 0.912X-0.070.

Determination of Phytate Content

The phytate content was determined by the method described by Maga (1998). To 2 g of each sample, 100 mL of 2% HCl was added and kept for 3 hours. These were filtered through a double layer of hardened filter paper. 50 mL of each filtrate was placed in a 250 mL beaker and 107 mL of distilled water was added in each case to reduce the acidity. 10 mL of 0.3 M ammonium thiocyanate solution was added to each solution as indicator. This was titrated with standard $FeCl_3$ solution, which contained 0.00459 g iron per mL. The end point was a slightly brownish yellow colour which persisted for 5 minutes. The total phytate content was calculated as:

% phytate = titre x 0.00195 x 1.19 x 100

RESULTS

Results of Proximate Analysis

The results of proximate analysis are shown in Table 1.

Table 1: Results of Proximate Analysis

Proximate Properties	Raw Sample %	Soaked Sample %	Cooked Sample %
Moisture Content	9.06±0.77	9.60±0.02	16.41±0.49
Ash Content	2.57±0.14	2.23±0.02	2.23±0.02
Crude Fibre Content	10.11±0.01	10.21±0.04	9.53±0.06
Crude Protein content	25.17±0.01	24.25±0.49	20.13±0.02
Crude Fat Content	2.21±0.02	2.17±0.01	1.53±0.01
Carbohydrate Content	51.19±0.01	51.02±0.14	49.81±0.02

Note: Values are mean ± standard deviation of duplicate determinations.

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Results of Mineral Composition

The results of mineral composition are shown in Table 2:

Table 2: Results of Mineral Composition

Mineral Elements	Raw Sample (ppm)	Soaked Sample (ppm)	Cooked Sample (ppm)
Sodium	29.50	25.50	21.30
Potassium	27.30	21.90	20.05
Magnesium	98.20	71.60	65.40
Calcium	126.60	102.90	98.40

Results of Heavy Metal Composition

The results of heavy metal composition are shown in Table 3.

Table 3: Results of Heavy Metal Composition

Heavy Metals	Raw Sample (ppm)	Soaked Sample (ppm)	Cooked Sample (ppm)
Lead	0.90	0.40	0.20
Cobalt	0.85	0.50	0.13
Iron	14.96	11.30	9.09
Zinc	9.50	6.10	5.80
Chromium	2.02	0.10	0.03

Results of Anti-nutritional Factors

The results of Anti-nutritional factors are shown in Table 4.

Table 4: Results of Anti-nutritional Factors

Anti-nutritional Factors	Raw Sample (mg/kg)	Soaked Sample mg/kg)	Cooked Sample (mg/kg)
Tannins	28.08±0.010	11.25±0.010	5.44±0.010
Oxalates	8.08±0.014	3.22±0.010	2.42±0.010
Cyanogenic Glycosides	94.32±0.010	49.86±0.010	43.71±0.010
Saponins	9.26±0.010	5.81±0.010	2.00±0.010
Phytates	2.27±0.010	1.71±0.010	0.36±0.010
Alkaloids	0.22±0.010	0.11±0.010	0.02±0.010

Note: Values are mean ± standard deviation of duplicate determinations.

DISCUSSION

The results of proximate analysis are shown in Table 1. The moisture content of the raw, soaked and cooked *S. stenocarpa* seed were found to be 9.06±0.77%, 9.60±0.02% and 16.41±0.49% respectively. The moisture contents of the soaked and cooked samples were lower than the raw one by 1.3 and 6.9%, respectively. Comparing these values with the World Health Organization (WHO) limit for moisture content, which is 18.80 % (AOAC, 2010), shows that the degree of susceptibility of *S. Stenocarpa* seed to microbial effect would be low (Gregory, 2005).

The ash content of the raw, soaked and cooked samples were found to be 2.57±0.14 %, 2.23±0.02 % and 2.23±0.02 % respectively. The ash of the raw sample was 0.3 % higher than those of the soaked and cooked samples. Comparing these values with the WHO limit of 6 % (Inuwa *et al.*, 2011), shows that the seed is moderately rich in mineral elements-the raw sample having a higher content than the soaked and cooked ones. Intake of the seed would therefore, not be of serious risk since all the samples showed less ash content than the WHO tolerable limit.

The crude fibre content of the raw, soaked and cooked samples were found to be 10.11±0.01 %, 10.21±0.04 % and 9.53±0.06% respectively. The crude fibre content of the soaked sample was found to be higher than those of the raw and cooked ones. This could be as a result of the bonding of water molecules with the seed components. Comparing the values with WHO limit of 10 % (Inuwa *et al.*, 2011) shows that cooking would be more effective in processing *S. Stenocarpa* seed for safe consumption than milling and soaking in water. The results also showed that the degree of digestibility of the seed on consumption would be best achieved by cooking, since crude fibre is important in enhancing the digestibility of food (Inuwa *et al.*, 2011).

Crude protein contents of the raw, soaked and cooked samples were found to be 25.17±0.01 %, 24.25±0.49 % and 20.13±0.02 % respectively. The crude protein content of the raw sample was 0.42 % and 5.1 % higher than those of the soaked and cooked samples respectively. The values are comparatively higher than the WHO limit of 20 % (AOAC, 2000). This also shows that consuming the raw and soaked seed would lead to excessive protein, resulting in antagonizing of insulin in the

adipose tissue (Tremblay *et al.,* 2007). However, with cooking, the WHO limit is almost achieved thereby making the protein content of the seed to be almost convenient for consumption.

The crude fat content was found to be 2.21±0.02 %, 2.17±0.01 % and 1.53±0.01 % for the raw, soaked and cooked sample respectively. The crude fat content of the raw sample was 0.17 % and 0.66 % higher than those of the soaked and cooked samples respectively. Comparing the crude fat contents with the WHO limit of standard range of 28-30 % (AOAC, 2000) shows that *S. Stenocarpa* seed contains a low concentration of fat, thus consuming it would not lead to mental fatigue and arteriosclerosis, since these are caused by excessive intake of fats (Sarubin *et al.,* 2007). However, it would be ineffective in production of adequate calories, and hence, sufficient energy in the body (Liu *et al.,* 2017).

The carbohydrate content was found to be 51.19±0.01%, 51.02±0.14 % and 49.81±0.02% for the raw, soaked and cooked sample respectively. Carbohydrate content of the raw sample was 0.97% and 1.35% higher than that of the soaked and cooked sample, respectively. Comparing the carbohydrate contents of the samples with the WHO tolerable range of 55-65 % (AOAC, 2000) shows that *S. Stenocarpa* seed would not be a very good and adequate energy producing food (Khowala, *et al.,* 2008).

The results of mineral elements composition of *S. Stenocarpa* seed are shown in Table 2. The sodium contents for the raw, soaked and cooked samples were found to be 29.50 ppm, 25.50 ppm and 21.30 ppm, respectively. These results show that soaking and cooking reduce the concentration of sodium in the seed, since the concentration in the raw sample was 8.2 % and 4.0 % higher than those of the soaked and cooked samples, respectively. Comparing these values with the WHO standard range of 200-250 ppm shows that *S. Stenocarpa* seed contains low concentration of sodium and therefore, would not be effective in maintaining osmotic pressure, acid-base and water balance (Soetan *et al.,* 2010).

The potassium content of *S. Stenocarpa* seed was found to be 27.30 ppm, 21.90 ppm and 20.05 ppm, for the raw, soaked and cooked samples respectively. Comparing these values with the WHO standard range of 470-490 ppm (Moscow and Jotivenkatachalam, 2012) shows that the seed contains low potassium concentration of which excessive consumption of it without adequate intake of other kinds of food would result in homeostatic and fluid imbalance, since potassium helps in maintaining homeostasis (Soetan *et al.,* 2010).

The magnesium contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 98.20 ppm, 71.60 ppm and 65.40 ppm respectively. The raw sample content was 26.6 % and 32.8 % higher than those of the soaked and cooked samples, respectively. The magnesium content of these samples are below the WHO recommended range of 375-400 ppm. Moreover, soaking and cooking further decreased the magnesium content, implying that these processing methods would lead to magnesium deficiency disease such as vasodialation and hyperaemia among consumers of the seed (Soetan *et al.,* 2010).

The calcium contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 126.60 ppm, 102.90 ppm and 98.40 ppm respectively. The calcium content of the raw sample was 23.7 and 28.2 ppm respectively higher than those of the soaked and cooked samples. The results show that soaking and cooking reduce the calcium content in *S. Stenocarpa* seed. Comparing the values of calcium content of this seed with the WHO recommended values of 800-1000 ppm (Soetan *et al.,* 2010) shows that the seed would not be a good source of dietary calcium and hence, would not enhance bone formation since calcium is effective in bone formation (Soetan *et al.,* 2010).

The results of heavy metal composition are shown in Table 3. The concentration of lead in *S. Stenocarpa* seed was found to be 0.90 ppm, 0.40 ppm and 0.20 ppm for the raw, soaked and cooked sample respectively. The raw sample was found to be higher in lead concentration than the soaked and cooked samples by 0.50 ppm and 0.70 ppm respectively. Comparing the lead contents of the samples with the WHO standard range of 0.50-0.60 ppm (AOAC, 2000) shows that raw *S. Stenocarpa* seed can result in lead poisoning, inhibiting kidney enzymes in the process of haemosynthesis (Moscow and Jotivenkatachalam, 2012). Thus, from the results, there is an indication that soaking and cooking before consumption would reduce the lead content of *S. Stenocarpa* seed to a tolerable level and thus, would eliminate the problem of lead poisoning in the seed.

The cobalt contents for the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 0.85 ppm, 0.50 ppm and 0.13 ppm respectively. The raw sample was 0.35 ppm and 0.72 ppm respectively higher than the soaked and cooked samples, respectively. Comparing the cobalt contents of the samples with the WHO permissible limit of 0.11-0.13 ppm (Soetan *et al.,* 2010) showed that cooking would be the best processing method to reduce cobalt content in *S. Stenocarpa* seed. This would therefore, lead to elimination of toxicity diseases such as goitre, hypothyroidism and heart failure, which result from excessive intake of Cobalt (Moscow and Jotivenkatachalam, 2012).

The iron contents for the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 14.96 ppm, 11.30 ppm and 9.09 ppm respectively. The iron content for the raw sample was higher than those of the soaked and cooked samples by 3.66 ppm and 5.87 ppm respectively. The iron contents of the samples are comparably higher than the WHO standard range of 5.00-6.00 ppm (Soetan *et al.,* 2010). This implies that consuming much quantity of *S. Stenocarpa* seed would result in toxicity diseases such as haemachromatosis (Moscow and Jotivenkatachalam, 2012).

The zinc contents for the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 9.50 ppm, 6.10 ppm and 5.80 ppm respectively. The concentration of zinc in the raw sample was higher than those of the soaked and cooked samples by 3.40 ppm and 3.70 ppm, respectively. The zinc contents of all the samples are lower than the WHO standard range of 12.00-15.00 ppm (Soetan *et al.,* 2010). As a result of the low zinc content in the samples, the seed would therefore, be devoid of any physiological problem caused by high concentration of zinc when consumed. It would rather, promote growth and prevent mental lethargy (Moscow and Jotivenkatachalam, 2012).

The chromium contents for the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 2.02 ppm, 0.10 ppm and 0.03 ppm respectively. The chromium content in the raw sample was higher than those of the soaked and cooked samples by 1.92 ppm and 1.99 ppm respectively. Comparing the chromium contents of the samples with the WHO standard range of 0.10-0.20 ppm showed that soaking would be the best way for obtaining tolerable and acceptable chromium content for consumption. Consuming the raw seed would therefore result in chromium toxicity disease such as stomach upset, skin rash, liver damage, nasal itch and cancer (Moscow and Jotivenkatachalam, 2010).

The results of Anti-nutritional properties are shown in Table 4. The tannin content of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 28.08±0.010 mg/kg, 11.25±0.010 mg/kg and 5.44±0.010 mg/kg respectively. Comparing these values with the WHO permissible limit of 20 mg/kg (Moscow and Jotivenkatachalam, 2012) shows that soaking and cooking would reduce the level of tannin in the seed; thus, enhancing safety in its consumption. Soaking and cooking would thus, lead to elimination of scratching that could be caused by high concentration of tannins (Moscow and Jotivenkatachalam, 2012) in the seed, since the raw sample contained a higher tannin level than the WHO permissible value.

The oxalate contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 8.08±0.014 mg/kg, 3.22±0.010 mg/kg and 2.42±0.010 mg/kg, respectively. The lethal dose for oxalate content of food is 5.5 mg/kg (Inuwa *et, al.,* 2011). The results show that soaking and cooking would reduce the oxalate content of *S. Stenocarpa* to a tolerable level, with cooking being more effective in achieving this than the soaking process. Consumption of the raw milled seed would lead to kidney damage due to high oxalate content (Inuwa, *et al.,* 2011).

The cyanogenic glycoside contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 94.32±0.010 mg/kg, 49.86±0.010 mg/kg and 43.71±0.010 mg/kg, respectively. Comparing these values with the WHO permissible limit of 50 mg/kg (Moscow and Jotivenkatachalam, 2012) shows that soaking and cooking would reduce the cyanogenic glycoside content of *S. Stenocarpa* seed to a tolerable level for human consumption as it would not interfere with aerobic respiratory system (Inuwa *et, al.,* 2011).

The saponin contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 9.26±0.010 mg/kg, 5.81±0.010 mg/kg and 2.00±0.010 mg/kg respectively. Comparing these values with the WHO permissible limit of 2.5 mg/kg shows that only the cooking method would

be adequately effective in reducing the saponin content of *S. Stenocarpa* seed to a tolerable level. The results of saponin content show that consumption of both raw and soaked *S. Stenocarpa* seed can lead to saponin toxicity resulting in haemolytic effects on red blood cells (Inuwa, *et al.*, 2011).

The phytate contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 2.27±0.010 mg/kg, 1.71±0.010 mg/kg and 0.36±0.010 mg/kg respectively. These results are comparably lower than the WHO permissible limit of 250 mg/kg for phytates (Moscow and Jotivenkatachalam, 2012). This implies that consumption of *S. Stenocarpa* seed, either in the raw, soaked or cooked form would not result in toxic effects of high phytate content. These effects include formation of insoluble salts with metals such as calcium, iron, zinc and magnesium in the intestine (Inuwa, *et al.*, 2011).

The alkaloid contents of the raw, soaked and cooked samples of *S. Stenocarpa* seed were found to be 0.22±0.010 mg/kg, 0.11±0.010 mg/kg and 0.02±0.010 mg/kg, respectively. These results show that both soaking and cooking would reduce the alkaloid content of *S. Stenocarpa* seed to concentrations that are lower than the WHO permissible limit of 0.2±0.01 mg/kg (Inuwa, *et al.*, 2011). The results also show that cooking is more effective in reducing alkaloid content in *S. Stenocarpa* seed than soaking. It therefore, implies that diseases resulting from alkaloid toxicity such as intestinal upsets and neurological disorders (Osagie, 1998) can be avoided by soaking and cooking the seed. However, it was shown that cooking the seed would be more effective in achieving this than soaking it.

CONCLUSION

The results obtained from this study reveal that soaking and cooking would have remarkable effect on *S. Stenocarpa* seed, by reducing various proximate properties, mineral and heavy metal composition as well as Anti-nutritional factors of the seed.The proximate, mineral elements and heavy metal compositions of the seed were shown to be reduced by soaking and cooking thereby reducing to some extent, its nutritional value alongside its toxicity. In a similar manner, the composition of the Anti-nutritional factors was generally reduced by soaking and cooking thereby reducing the toxic effect of these factors, which could lead to various diseases and ailments on consumption of the seed.

It could therefore, be concluded that the two processing methods (soaking and cooking) are important in treating *S. Stenocarpa* seed for the purpose of consumption, since these processes would remarkably reduce the toxic effect of the seed, thus making it more suitable for consumption than the direct milling of the raw seed. However, cooking would be more effective than soaking in reducing the toxic effect of the seed for human consumption. Since the effect of the two processing methods were not reasonably detrimental to the nutritional properties, then, they could be very suitable in treating the seed for human consumption.

RECOMMENDATION

This research study reveals that both soaking and cooking are important processing methods in lowering the toxicological effect of *S. Stenocarpa* seed, with cooking having a higher effect generally. Since the effects of these processes on the nutritional components of the seed were not significantly detrimental on it; we therefore, recommend them for the purpose of consumption of the seed.

More work should be carried out on other processing methods such as roasting and peeling of the outermost part of the seed to determine their effects on these parameters. Further work should also be carried out to determine the vitamin contents of the seed and how it could be affected by these processing methods.

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