European Journal of Food Science and Technology

Vol.3, No.3, pp.45-69, July 2015

Published by European Centre for Research Training and Development UK (www.eajournals.org)

EFFECT OF PROCESSING ON THE NUTRITIONAL AND ANTI NUTRITIONAL PROPERTIES OF *CANAVALIA PLAGIOSPERMA PIPER* SEEDS

Alagbaoso, S.O., Nwosu, J. N., Njoku, N.E., Umelo, M.C., Eluchie, C. and Agunwa, I.M.

Department of Food Science and Technology, Federal University of Technology, P.M.B 1526, Owerri, Imo State, Nigeria.

Alagbaoso, S .O.

ABSTRACT: *The effect of heat processing on the nutritional and anti nutritional qualities of oblique -seeded jack bean (Canavalia plagiosperma piper) was studied. Raw seeds of Canavalia plagiosperma (Oblique seeded Jack bean) were autoclaved (at 121^{0}C, 15lb for 25, 30 and 35 minutes) and cooked (at 100^{0}C for 30, 40 and 50 minutes). The proximate composition and anti-nutrients of the processed and raw samples were determined. The proximate composition showed that moisture content of raw seed was 8.26%, 35 minutes autoclaving increased it to 8.53% while 50 minutes cooking increased it to 8. 84%. Autoclaving reduced protein content from 31.54% to 31.28% while cooking reduced it from 31.54% to 28.86%. The ash content was reduced from 3.17% to 2.95% by autoclaving and from 3.17% to 2.51% by cooking. Autoclaving showed increasing effect on fat and energy content,(0.82-9.23%) and (1635.66-1637.94 KJ/g) respectively. The fibre content of the raw seed was found to be 0.94%, which was reduced to 0.88% by autoclaving and 0.62% by cooking. Cooking significantly increased the carbohydrate content (47.36-52.15%). The processing treatments showed significant effect (P≤0.05) on each parameter. Six (6) anti-nutrients (Saponin: 2.45%, Phytic acid: 3.15%, Tannin: 1.02%, Oxalate: 1.48%, Phenol: 0.34%, Trypsin Inhibitor: 11.53Tu/g) were determined in the raw seed. The six processing treatments given to the seed showed a general reduction trend on these six anti-nutrients at different rates and levels. From the results in Table 3 and 4, autoclaving was the best processing method for phytic acid, and phenol while cooking was the best processing method for tannin, trypsin inhibitor, saponin and oxalate.*

KEYWORDS: Canavalia plagiosperma piper, autoclaving, cooking, anti-nutrients, Proximate.

INTRODUCTION

Oblique- seeded jackbean or giant bean (*Canavalia plagiosperma piper*) is also called *Riesenbohene* in German, *Pellarde losgentills* or *Promo gigante* in Spanish, and "ukpo Ghana" in the Eastern part of Nigeria. *Canavalia plagiosperma* belongs to the family of *leguminosae* known as fabaceae and subfamily of *papilionoideae*,. The genus comprises of approximately 70-75 species of tropical origin. *Canavalia plagiosperma piper* is a hybrid of *Canavalia ensiformis* (Jackbean) and *Canavalia gliadiata* (sword bean) (Akinmutimi, 2004).*Canavalia plagiosperma* is a high forage and seed yielding tropical legume with high energy and protein content and quality for Nigerian livestock industry (Odoemelam, 2007). Initial effort at determining the nutritional

ISSN 2056-5798(Print), ISSN 2056-5801(online)

composition of the raw unprocessed dry seed of C. *plagiosperma* suggests that it has crude protein content of 35.53% which could be used to fortify cereal based diets. Recent research by Esonu *et al*., (2013) showed that raw seed of *Canavalia plagiosperma* contains crude protein 36.11%, moisture 19.35%, crude fibre 5.12%, ash 1.80%, carbohydrate 51.46%, crude fat 5.48%, dry matter 80.65%. Also the nutritive and protein quality of the seed as shown by some studies seems to be similar to that of most of the edible legume grains and hence, they are advocated to be a good source for extending protein sources (Moreina *et al*., 1993).The use of *Canavalia plagiosperma* (raw) as a high protein food and forage crop for some countries like Mexico, Brasil and Central America has been documented(Odoemelam, 2007).In "Ikwuano"Umuahia in Abia State of Nigeria, the seed is used as soup thickener, but it was reported that the thickening effect is low which reduced its usage as a soup thickener (Esonu,2009).Also, the young pods and immature seeds of *canavalia plagiosperma* are used generally as vegetables. The immature pods are made into a dish directly or often boiled with water; also the immature seeds are often consumed as curries and as a substitute for mashed potatoes (Esonu,2009).Despite the desirable nutritive features of C. *plagiosperma* seed, it is not extensively utilized as food for man and /or feed for ruminants mainly due to the presence of certain anti-nutritional compounds(Udedibie *et al*.,2000;Esonu,2009).

Some of the problems associated with Canavalia plagiosperma is unavailability due to poor utilization and unfamiliarity. There are also uncertainties concerning the appropriateness of heat treatment and the degree/timing of such treatments. *Canavalia plagiosperma* has been noted by Esonu, (2009) to contain some anti- nutrients. Also, Odoemelam, (2007) and Moreina *et al*., (1993) documented that the raw seed contains 35.53% of crude protein. Despite the high protein content of the seed, yet it is not generally utilized as food or in food formulations for human consumption. This could be as a result of anti-nutrients contained by the seed (Moreina *et al*., 1993)**.**

The main objective of this work is to study the effect of heat treatment (Autoclaving) on the nutritional and heamatological parameters of oblique-seeded jackbean seeds (*Canavalia plagiosperma piper*)

MATERIALS AND METHOD

MATERIALS

Source of Materials.

The fresh seeds of *Canavalia plagiosperma* for this study were obtained from Ikwuano Umuahia in Abia State of Nigeria

All equipment and chemicals used were available at Reliable research laboratory services Umuahia, Abia state; National Root Crops Research Institute (NRCRI) Umudike; and Federal University of Technology (FUTO), Owerri, Imo State. All the chemicals used were of analytical grade.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

METHODS

Sample Preparation

The healthy seeds of *C. plagiosperma were* dehulled by parboiling at the temperature of 100^{O}C for 5 minutes to ease decoating of the seeds, after which the coats were removed manually. Then, the dehulled /decoated seeds were dried using a moisture extraction oven (Gallenkamp hot box oven) at the temperature of 60^{0}C for 3 hours.

The decoated seeds were divided into 2 batches. One batch was further divided into 3 portions, the 3 portions were cooked at the temperature of 100^{O}C but at different cooking times of 30,40, and 50 minutes respectively in a seed to water ratio of 1:10 (w/v), The cooked seeds were rinsed with distilled water and then dried using a moisture extraction oven (Gallenkamp hot box oven) at 60^{O}C for 3 hours. The second batch was also divided into 3 portions. The 3 portions were autoclaved at 15 lb (121^{O}C) but for different time intervals of 25,30 and 35 minutes respectively, rinsed with distilled water and then dried at 60^{o}C for 3 hours. The processed dried seeds were milled and kept in an air tight container to avoid moisture reabsorption. Samples were evaluated for anti-nutritional factors and proximate composition. The raw seeds were also dehulled, milled and stored in an air tight container which was analysed as control. .

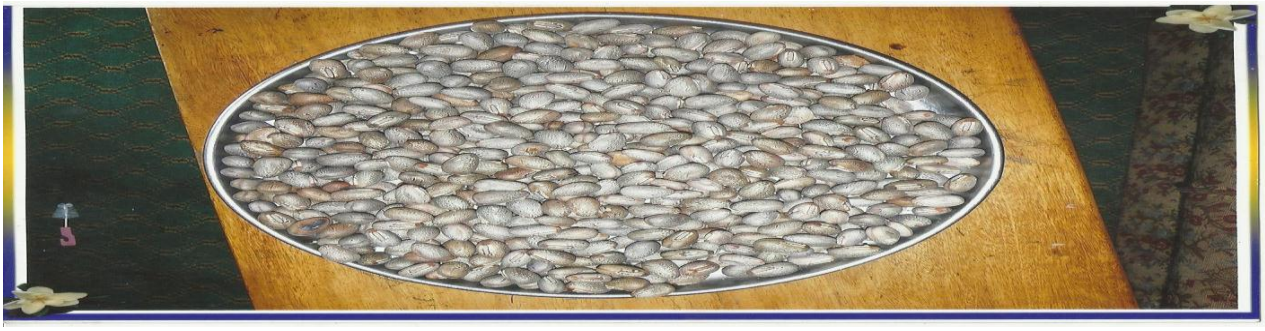

Plate 1: UNDEHULLED, RAW *CANAVALIA PLAGIOSPERMA* SEEDS.

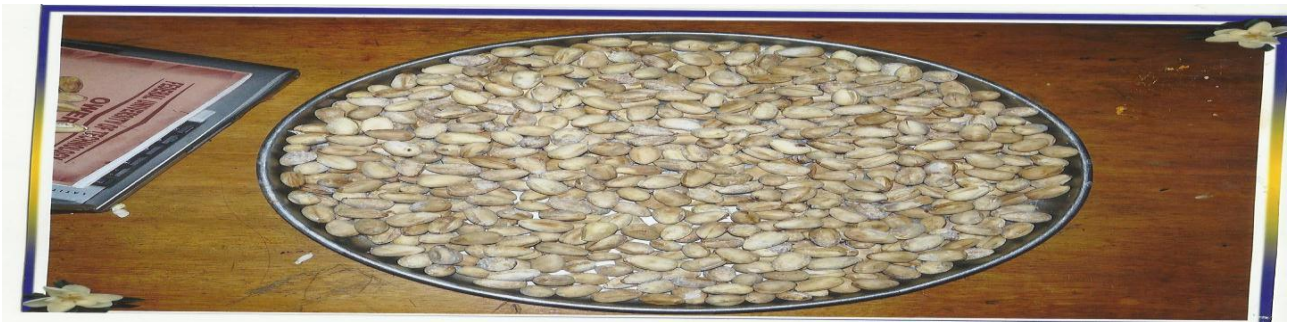

Plate 2: DEHULLED, RAW *CANAVALIA PLAGIOSPERMA* SEEDS

ISSN 2056-5798(Print), ISSN 2056-5801(online)

PROXIMATE ANALYSIS

The proximate analysis was carried out according to the methods outlined by the Association of Official Analytical Chemists (A.O.A.C, 2000).

Moisture content

Two grams of the dried ground sample were weighed into a crucible and placed in an oven at a controlled temperature of 105^0C. The sample was allowed to dry in the oven to a constant weight.

The percentage moisture content was then expressed as the percentage of the original weight of the sample. The experiment was carried out in triplicates the percentage moisture was thus calculated:

$$\text{Percentage moisture} = \frac{W_2 - W_3}{W_2 - W_1} X100$$

Where W_1 = Mass of dried crucible

W_2 = Mass of dry crucible + Sample before drying

W_3 = Mass of dry crucible + Sample after drying

Ash content

Two grams of the dried sample was measured into a crucible and placed in the muffle furnace at 550^0C until it was burnt to ash. The crucible and content were then allowed to cool in a desiccator and weighed. This was done repeatedly until a constant weight of the ash was obtained.

The percentage ash content was then expressed as percentage of the original weight of the sample on dry basis. The experiment was done in triplicates. Percentage ash content was thus calculated:

ISSN 2056-5798(Print), ISSN 2056-5801(online)

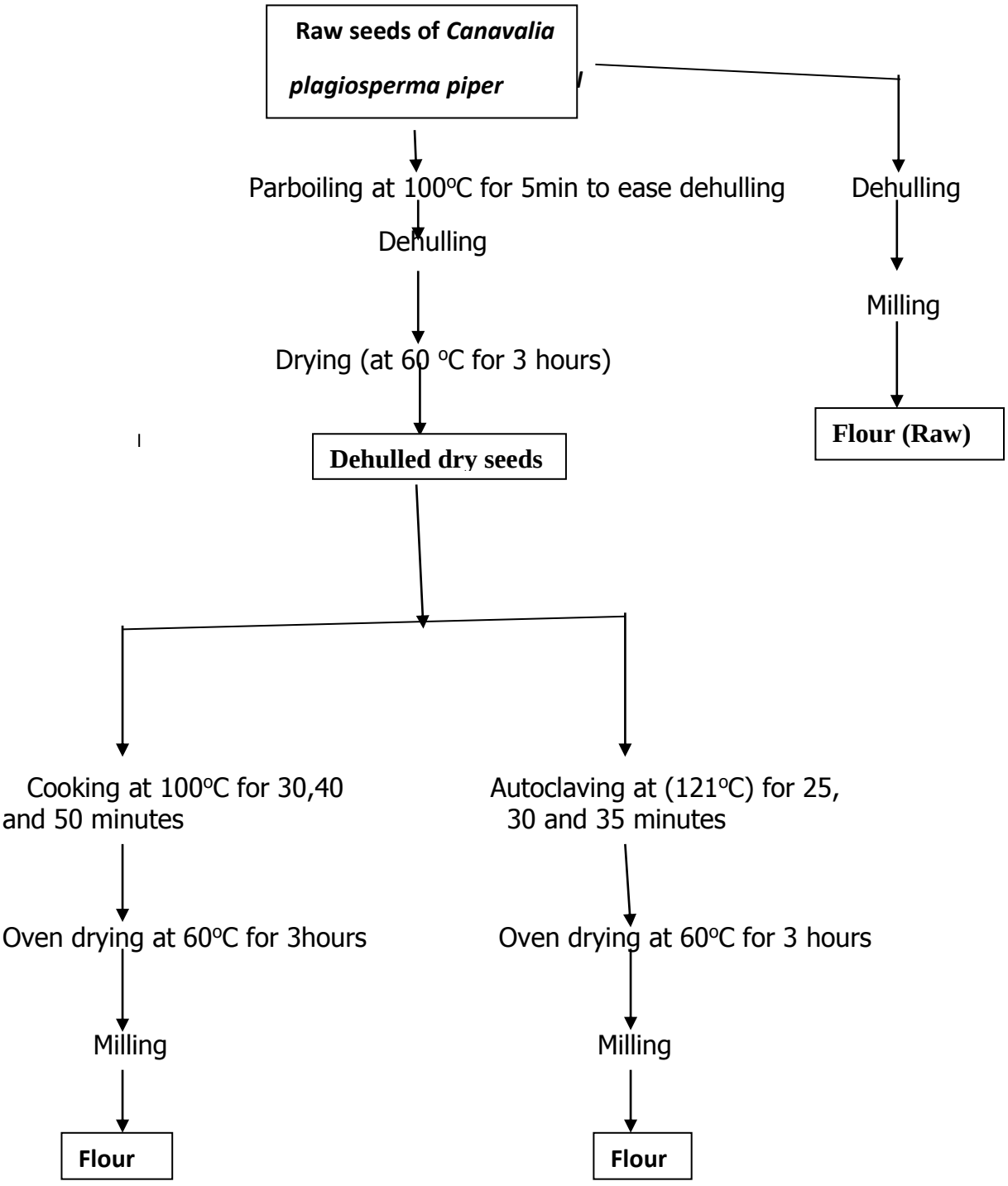

Fig 1 Flow chart for the production OF C. *plagiosperma* flour Samples.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

$$\% \text{ Ash} = \frac{W_3 - W_2}{W_1} \times 100$$

Where W_1 = Weight of sample analyzed

W_2 = Weight of empty crucible

W_3 = Weight of crucible + Ash

Crude fat content

Ten (10) grams of the dried ground sample was weighed and wrapped with a clean filter paper and placed into the thimble in a soxhlet extractor. A round bottom flask was cleaned, weighed and 120ml of food grade hexane added. The flask was connected to the sample holder of the soxlet extractor and heated slowly on a mantle for 6 hours. Refluxed hexane was recovered and the flask containing the lipid was dried in the moisture extractor in the oven at 60^0C for few minutes to remove any residual solvent. After drying, the flask containing the oil was cooled in a desiccator and reweighed.

By difference, the mass was determined and expressed as the percentage of the fat thus:

$$\text{Percentage (\%) Crude fat} = \frac{Weight\ of\ fat}{Weight\ of\ sample} \times 100$$

Crude fibre content

Two grams (2g) of the defatted dried sample was transferred into a 100ml flask, followed by addition of 200ml of 1.25% sulphuric acid. The flask was then placed in a digest apparatus on a pre-adjusted hot plate and boiled for 30 minutes with rotation of the flask periodically to prevent solid from adhering to the bottom of the flask. At the end of 30 minutes, the mixture was allowed to stand for one minute, and filtered immediately through the Buchner funnel lined with a muslin cloth. The insoluble matter was washed into the flask for alkali digestion using 0.3M sodium hydroxide. The digest was boiled for 30 minutes and was allowed to cool for one minute and then filtered using a muslin cloth as before. The residue was then washed successively with 0.1MHCl and finally with boiling water until it was free of acid. It was then washed twice with alcohol and thrice with ether. The residue or insoluble matter was then transferred into a crucible and dried at 105^0C in an oven to a constant weight, cooled and weighed. It was then ashed at 550^0C, cooled and weighed. The difference in weight after ashing was then calculated as the fibre content of the sample and was expressed as a percentage of the original weight. The percentage crude fibre content was this calculated:

ISSN 2056-5798(Print), ISSN 2056-5801(online)

% Crude Fibre = $\frac{W_2 - W_3}{W_1} \times 100$

Where W_1 = Weight of sample

W_2 = Weight of sample and crucible after drying at 105^0C

W_3 = Weight of sample (as ash) and crucible after ashing

Crude protein content

The dried ground sample (0.6g) was weighed into an already dried kjeldahl flask. A few drops of water was added to the sample to moisten it, using a burette, 3ml of conc. H_2SO_4 acid was added into the flask followed by the addition of 0.5g of $CuSO_4$. The content of the flask was then digested in a fume cupboard with occasional stirring until a clear solution was obtained. The flask was allowed to cool and a small quantity of distilled H_2O added. The digest was then transferred into 100ml volumetric flask and the initial volume recorded. The mixture was shaken thoroughly to obtain a homogenous solution.

The mixture was now ready for distillation. The distillation apparatus was steamed for 30 minutes as to get rid of traces of alkali left in the flask. With the aid of a pipette, 10ml of the digest was added to the micro distillation apparatus using a funnel. 10ml of 50% NaOH solution was put in the funnel with measuring cylinder, with stopper glass rod in place. A water condenser set was connected with a 100ml conical flask used as a receiver which contained 10ml of 4% boric acid and two (2) drops of mixed indicator (bromocressol green/methyl red). The drop end of the condenser was immersed well into the boric acid. The stopper glass rod was gradually removed to allow the NaOH solution to thoroughly mix with the sample digest solution. The funnel was filled with distilled H_2O and the steam generator was closed at the top and steam passed into the distillation set. NH_3 was liberated and was distilled into 10ml 4% boric acid for 15 minutes. 50ml of the distillate of blue/green colour was collected and the drip end of the condenser was washed with distilled water into the 100ml conical flask containing the distillate. The distillate was then titrated against 0.1N hydrochloric acid till it changed to pink colour.

A reagent blank was run as a control and the protein content was then calculated by multiplying Nitrogen obtained with the factor of 6.25, expressed on dry basis. The experiment was carried out in triplicates. The formula for % crude protein is given below:

% Protein = % N_2 x 6.25

% N_2 = $\left[\frac{100}{W} \times \frac{N \times 14}{1000} \times \frac{V_t}{Va}\right] T - B$

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Where W = Weight of sample

N = Normality of titrant

Vt = Total digest volume

Va = Volume of digest analyzed

T = Sample titre value

B = Blank titre value

Carbohydrate content

Carbohydrate content was determined by the difference method. This was done by summing up the (% moisture, % protein, % fat, % ash and % crude fibre) contents and then subtracting their sum from 100. It was also expressed in percentage (%).

DETERMINATION OF ANTI-NUTRITIONAL FACTORS

Determination of tannins

The Folin-Denis spectrophotometric method was used. The method was described by Ezegbe (2012). A measured weight of each sample (1.0g) was dispersed in 10ml distilled water and agitated. This was left to stand for 30min at room temperature, being shaken every 5min. At the end of the 30mins, it was centrifuge and the extract gotten. 2.5ml of the supernatant (extract) was dispersed into a 50ml volumetric flask. Similarly 2.5ml of standard tannic acid solution was dispersed into a separate 50ml flask. A 1.0ml folin-denis reagent was measured into each flask, followed by 2.5ml of saturated Na_2CO_3 solution. The mixture was diluted to mark in the flask (50ml) and incubated for 90min at room temperature. The absorbances were measured at 250nm in a Genway model 6000i electronic spectrophotometer. Readings were taken with the reagent blank at zero. The tannin content was given as follows;

$$\% \text{ Tannin} = \frac{A_u}{A_S} \times C \times \frac{100}{W} \times \frac{V_f}{V_a} \times D$$

Where; A_u = Absorbance of test sample

A_s = Absorbance of standard tannin solution

C = Concentration of standard tannin solution

W = weight of sample used

V_f = total volume of extract

ISSN 2056-5798(Print), ISSN 2056-5801(online)

V_a = Volume of extract analysed

D = Dilution factor (if any)

Determination of Trypsin Inhibitor

This was done using the spectrophotometric method, described by Nwosu (2011). A measured weight (10g) of the test sample was dispersed in 50ml of 0.5M NaCl solution and stirred for 30 minutes at room temperature. It was centrifuged and the supernatant filtered through whatman No.42 filter paper. The filtrate was used for the assay. Standard trypsin was prepared and used to treat the substrate solution (N-benzoyl-DI-arginine-P-anilide; BAPA).The extent of inhibition was used as a standard for measuring the trypsin inhibitory activity of the test sample extract into a test tube containing 2ml of extract and 10ml of the substrate (BAPA) 2ml of the standard trypsin solution was added. Also 2ml of the standard trypsin solution was added in another test tube containing only 10ml of the substrate. The latter served as the blank.

The content of the tubes were allowed to stand for 30 minutes and then absorbance of the solution measured at 430nm wavelength with a colorimeter (Jenyway 6051).One trypsin activity unit inhibited is given by an increase of 0.01 absorbance unit at 430nm.Trypsin unit inhibited was calculated thus:

Trypsin unit inhibited $= \frac{A_u}{A_s} \times 0.01 \times F$

Where A_u= Absorbance of test sample

A_s =Absorbance of standard (uninhibited) sample

F =Experimental factor given as: $\frac{V_f}{V_a} \times \frac{1}{W}$

Where V_f =Total volume of extract

Va =Volume of extract analyzed

W =Weight of sample analyzed

Determination of phytate.

The method described by Nwosu (2011) was used.The phytic acid in the samples was precipitated with excess $FeCl_3$ after extraction of 1g of each sample with 100ml 0.5N HCl. The precipitate was converted to sodium phytate using 2ml of 2% NaOH before digestion with an acid mixture containing equal portions (1ml) of conc. H_2SO_4 and 65% $HClO_4$. The liberated phosphorus was

ISSN 2056-5798(Print), ISSN 2056-5801(online)

measured colorimetrically (Jenway 6051 Colorimeter) at 520nm after colour development with molybdate solution.

The percentage phytate was thus calculated:

$$\% \text{ Phytate} = \frac{100}{W_t} \times \frac{au}{as} \times C \times \frac{V_t}{V_a}$$

Where W = weight of sample used

au = absorbance of test sample

as = absorbance of standard phytate solution

C = Concentration of standard phytate solution

Vt = Total volume of extract

Va = Volume of extract analyzed

Determination of Saponins

This was done by the double solvent extraction gravimetric method (A.O.A.C.,1990).Two grams(2g) of the processed sample was mixed with 100ml of 20% aqueous ethanol solution and incubation for 12hour at a temperature of 55^{o}C with constant agitation. After that, the mixture was filtered through whatman No 42 grade of filter paper. The residue was re-extracted with 50ml of the ethanol solution for 30 minutes and the extracts weighed together.

The combined extract was reduced to about 40ml by evaporation and then transferred to a separating funnel and equal volume (40ml) of diethyl ether was added to it. After mixing well, there was partition and the upper layer was discarded while the lower aqueous layer was re-extracted with the ether after which its pH was reduced to 4.5 with drop wise addition of NaOH solution.

Saponin in the extract was taken up in successive extraction with 5% of NaCl solution and evaporated with a water bath in a previously weighed evaporation dish. The saponin was then dried in an oven (Gallenkamp Hot box Oven) at 60^{0}C (to remove any residual solvent), cooled in a desiccator and re-weighed. The saponin content was calculated as shown below:

$$\% \text{ Saponin} = \frac{W_2 - W_1}{W}$$

Where W = Weight of sample used

ISSN 2056-5798(Print), ISSN 2056-5801(online)

W_1 = Weight of empty evaporation dish

W_2 = Weight of dish + saponin extract

Determination of Oxalate

This was carried out by the procedures described by Nwosu (2011).One gram (1g) of the sample was weighed into a 100mi beaker,20ml of 0.30N HCl was added and warmed to (40-50^{O}c) using magnetic hot plate and stirred for one hour. It was extracted three times with 20ml flask. The combined extract was diluted to 100ml mark of the volumetric flask.

The oxalate was estimated by pipetting 5ml of the extract into a conical flask and made alkaline with 1.0ml of 5N ammonium hydroxide. A little indicator paper was placed in the conical flask to enable knowing the alkaline regions.It was also made acid to phenolphthalein (3 drops of this indicator added, excess acid decolorizes solution) by dropwise addition of glacial acetic acid. 1.0ml of 5% $CaCl_2$ was then added and the mixture allowed to stand for 3 hours after which it was then centrifuged at 300 rpm for 15 minutes. The supernatant was discarded. 2ml of 3N H_2SO_4 was added to each tube and the precipitate dissolved by warming in a water bath (70 – 80^{o}C). The content of all the tubes was carefully poured into a clean conical flask and titrated with freshly prepared 0.01N $KMnO_4$ at room temperature until the fist pink colour appeared throughout the solution. It was allowed to stand until the solution became colourless.The solution was then warmed to 70 -80^{o}C and titrated until a permanent pink colour that persisted for at least 30 seconds was attained.

The percentage (%) oxalate was thus calculated:

$$\% \text{ Oxalate} = \frac{100}{W} \times 0.00225 \times Total\ titre\ volume$$

Where W = Weight of sample used

Determination of total phenols.

This was determined by the folin-ciocateau spectrophotometer method (AOAC, 1990). The total phenols were extracted in 0.2g of the sample with 10ml concentrated methanol. The mixture was shaken for 30 minutes at room temperature. The mixture was centrifuged at 500rpm for 15 minutes and the supernatant (extract) was used for the analysis.

1ml portion of the extract from each sample was treated with equal volume of folin-ciocalteau reagent followed by the addition of 2ml of 2% Na_2CO_3 solution. Standard phenol solution was prepared and diluted to a desired concentration.

Iml of the standard solution also treated with the Folin-ciocateau reagent and Na_2CO_3 solution. The intensity of the resulting blue colouration was measured (absorbance) in a colorimeter (Jenway 6051) at 540nm wavelength.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Measurement was made with a reagent blank at zero. The phenol content as calculated using the formula below:

$$\% \text{ Phenol} = \frac{100}{W} \times \frac{au}{as} \times C \times \frac{V_t}{V_a} \times D$$

Where W = weight of sample

au = absorbance of test sample

as = absorbance of standard phenol solution

C = Concentration of standard phenol solution

V_t = Total volume of extract

V_a = Volume of extract analyzed

D = Dilution factor (if any)

DATA ANALYSIS

The results obtained from the data were subjected to Analysis of variance (ANOVA) according to Onuh and Igwemma (2000) and SAS (1999).Significant means at $p \leq 0.05$ were separated using Fisher's least significant difference (LSD) test (Onuh and Igwemma, 2000).

RESULTS AND DISCUSION

Effect of autoclaving on the proximate composition of *Canavalia plagiosperma* seed.

The results of the effect of autoclaving on the proximate composition of *Canavalia plagiosperma piper* seed is shown in Table 1. Results of the moisture content (Table 1) showed that autoclaving had significant increasing effect on the moisture content of *Canavalia plagiosperma* seed, though the moisture content is still low. There was a significant difference ($P \leq 0.05$) in moisture content among the treated samples and the raw sample; also there was no significant difference ($P \geq 0.05$) in the moisture content of 30 and 35 minutes autoclaved samples. Moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination (Aruah *et al*., 2012), indicating that autoclaved seeds of *Canavalia plagiosperma* piper can be processed to flour and kept for sometime without microbial spoilage and deterioration in quality.

The crude protein content of raw *Canavalia plagiosperma* seed (31.54%) was higher when compared to certain common legume *Phaseolus vulgaris* (20.9%); *Lenus culinaris* (20.6%) and

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Cicer arietinum (18.5%) (Costa *et al*., 2006). It is also higher than that of *Canavalia gladiata* (27.48%) and *Canavalia ensiformis* (30.62%) (Arun *et al*, 2004). On the other hand, the crude protein content of *Canavalia plagiosperma* (31.54%) is lower than that of *Canavalia cathartica* (35.5%) and *Canavalia maritime* (34.1%) (Arun *et al*., 2004).There was no significant difference in the protein content of the autoclaved samples. It is generally known that any plant that provides more than 12% of their caloric value from protein is considered to be a good source of protein. Thus *Canavalia plagiosperma piper* is a good source of protein. The effect of autoclaving on the protein content of the seed is very slight.

Ash represents the mineral matter left after food material is burnt in oxygen (Enwereuzoh *et al*., 2015).It is used as a tool to measure the mineral content in any sample (Enwereuzoh *et at*., 2015). C. *plagiosperma piper* had moderately high value of ash (3.17%),which indicates that the seed has good mineral content, hence, can serve as a viable tool for nutritional evaluation (Lienel, 2002). Autoclaving had significant decreasing effect on the ash content but the autoclaved samples were not significantly different ($p \geq 0.05$).

Table 1: Effect of autoclaving on the proximate composition of *Canavalia plagiosperma* seed.

	Sample			
Parameters	**Raw**	**25min autoclaved**	**30 min autoclaved**	**35mim autoclaved**
Moisture (%)	$8.26^{g}\pm0.01$	$8.34^{f}\pm0.01$	$8.44^{d}\pm0.03$	$8.53^{d}\pm0.03$
Crude Protein (%)	$31.54^{a}\pm0.01$	$31.41^{b}\pm0.06$	$31.35^{bc}\pm0.01$	$31.28^{cd}\pm0.02$
ASH (%)	$3.17^{a}\pm0.23$	$2.97^{bc}\pm0.03$	$2.96^{bc}\pm0.02$	$2.95^{c}\pm0.01$
Crude fibre (%)	$0.94^{a}\pm0.01$	$0.93^{a}\pm0.02$	$0.92^{a}\pm0.0$	$0.88^{b}\pm0.02$
Crude fat (%)	$8.82^{b}\pm0.03$	$8.83^{b}\pm0.02$	$8.98^{b}\pm0.02$	$9.23^{a}\pm0.02$
Carbohydrate (%)	$47.36^{h}\pm0.11$	$47.46^{g}\pm0.04$	$47.29^{hi}\pm0.06$	$47.23^{i}\pm0.01$
Total energy value(KJ/g)	$1635.06^{c}\pm2.31$	$1635.21^{c}\pm2.30$	$1637.84^{c}\pm1.73$	$1637.94^{c}\pm1.73$
Dry Matter (%)	$91.75^{d}\pm0.03$	$91.46^{de}\pm0.01$	$91.56^{de}\pm0.02$	$91.45^{de}\pm0.02$

The crude fibre content of *Canavalia plagiosperma* seed (0.94%) was very low as shown in Table 1 and is lower when compared to some legumes like *Lima bean* (2.1%), soya bean (2.2%), pear bean (1.7%) *Lentil* (1.1%) and *Lupin* (1.5%) (Potter and Hotchkiss, 1995). Fibre has some physiological effect in the gastrointestinal track (Effiong *et al*., 2009) and low fibre in diet is undesirable as it may cause constipation.This implies that the low fibre content reported in this work for *Canavalia plagiosperma* suggests that consuming this seed alone may cause constipation. The crude fibre level in the raw, 25 and 30 minutes autoclaving were not significantly different ($p \geq 0.05$).

ISSN 2056-5798(Print), ISSN 2056-5801(online)

The crude fat content of raw seeds of *Canavalia plagiosperma* (8.82%) were found to be higher when compared to certain common legumes such as *Cicer arietinum* (4.16%); *Vigna mungo* (0.45%); *Vigna radiata* (0.71%); *Vigna aconitifolia* (0.69%) and *Phaseolus vulgaris* (0.9%) (Belmer *et al*., 1999). Its crude fat content is also higher when compared to that of *Pisium* sativum (2.34%); *Cicer arietinum* (6.69%); *Lenus culinaris* (2.15%) (Costa *et al*; 2006); *Canavalia ensiformis* (5.8%); *canavalia Cathartica* (1.3%); canavalia maritime (1.7%) and canavalia gladiata (7.84%) (Arun *et al*, 2004).

The crude fat content of the raw and processed samples are presented in Table 1.The autoclaved samples contained higher level of crude lipid. This is in consonance with that of an earlier report on certain autoclaved under-utilized legumes such as *Abrus precatorius, Mucuna pruriens var. utilis* and *Entada scandens* which showed that they have higher crude fat (Pugalenthi *et al*., 2007 and Vadivel *et al*., 2008).

The crude fat content of 8.82% for raw *Canavalia plagiosperma* seed indicate that it is not an oil seed when compared to soya bean that has up to 23.1% fat content (potter and Hotchkiss, 1995). The crude fat content increased with increased processing time (Table 1). There was no significant difference ($p \geq 0.05$) between the raw sample and 25 and 30 minutes autoclaved sample.

The carbohydrate content of raw *Canavalia plagiosperma* seed (47.36%) and that of autoclaved samples are shown in Table 1. The processing treatments had significant effects on the carbohydrate content of the seed except for 30 minutes autoclaving. The carbohydrate content (47.36%) of raw *Canavalia plagiosperm*a is lower than that of most legume like *Bambara groundnut* (65%), broad bean (56.9%), chick peas (60.9%) etc (Okaka, 1997) Its value (47.36%) was also higher than that of soya beans (32%), groundnut (21.0%) etc. (Okaka, 1997).The carbohydrate value(47.36%) of C. *plagiosperma* is fairly high. Carbohydrate provides energy to the cells in the body, particularly the brain, which is the only carbohydrate –dependent organ in the body (Enwereuzoh *et al*., 2015). It is necessary for maintenance of the plasma level, it spares the body protein from being easily digested and helps to prevent the using up of protein.The fairly high carbohydrate content found in Canavalia *plagiosperma piper* suggests high caloric value.

The energy value (1635.06 kJ/g) of *Canavalia plagiosperma* raw seed (Table 1) was higher than that of some legumes like *Canavalia cathertica* (1520.0kJ/g), *Canavalia maritime* (1586.0kJ/g), *Canavalia ensiformis* (1632kJ/g) (Arun *et al*., 2004), *Mucuna pruriens Var.utilis* (1541.0kJ/g)(Vadivel and pugalenthi, 2007),and lower than that of *Canavalia gladiata* (1694.0 kJ/g) (Arun *et al*., 2004). The energy values were dependent on the metabolic fuels which are protein, carbohydrate and fat, since it was computed from them.There was no significant effect ($p \geq 0.05$) on the energy levels of the autoclaved samples.There was no significant different ($P \geq 0.05$) on the dry matter level of autoclaved samples.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Effect of cooking on the proximate composition of *Canavalia plagiosperma* seed.

The effect cooking on the proximate composition of *Canavalia plagiosperma* seed is presented in Table 2 above. Results of the moisture content (Table 2) showed that the cooking had significant effect on the moisture content of *Canavalia plagiosperma* seed. Cooking significantly increased the moisture content of *Canavalia plagiosperma* seed. The 50 minutes cooking had the most significant increasing effect on the moisture content raising it from its raw seed value of 8.26% to 8.84%. This may be as a result of the moisture it imbibed during cooking. There was a significant difference ($P \leq 0.05$) in moisture content among the treated samples and the raw sample.

The crude protein content of raw *Canavalia plagiosperma* seed (31.54%) was higher when compared to certain common legume such as Phaseolus *vulgaris* (20.9%); *Cicer arietinum* (18.5%) etc (Costa *et al*., 2006) .On the other hand, the crude protein content of *Canavalia plagiosperma* (31.54%) is lower than that of *Canavalia cathartica* (35.5%) and *Canavalia maritime* (34.1%) (Arun *et al*., 2004).Cooking significantly decreased the crude protein content of *Canavalia plagiosperma* which might be as a result of leaching of soluble components of the protein into the cooking water.Akinmutimi *et al*., (2002) obtained similar lower crude protein values in cooked and soaked sword bean (*Canavalia gladiata*). There was significant difference ($P \leq 0.05$) between the raw sample and the processed samples in protein content.

Cooking had a significant decreasing effect on the ash content. The raw seed of *Canavalia plagiosperma* had an ash content of 3.17%. The substantial reduction of ash content (17%) in the cooked seeds samples of *Canavalia plagiosperma* might be due to the increased leaching out of both micro and macro minerals into the cooking medium. The crude fibre content of *Canavalia plagiosperma* seed (0.94%) was very low as shown in Table 2. Its crude fibre content of (0.94%) in Table 2 is lower when compared to some legumes like soya bean (2.2%), pear bean (1.7%) and *Lentil* (1.1%)(Potter and Hotchkiss, 1995) and is also very low when compared to other *Canavalia* species such as *Canavalia carthartica* (7.0%), *Canavalia maritima* (10.2%), *Canavalia ensiformis* (5.08%) and *Canavalia gladiata (2.0%)* (Arun *et al*, 2004).There was significant decreasing effect in the crude fibre content during cooking.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Table 2: Effect of Cooking on the proximate composition of *Canavalia plagiosperma* seed.

Parameters	Sample			
	Raw	30min Cooked	40 min Cooked	50mim Cooked
Moisture (%)	$8.26^{g}\pm0.01$	$8.64^{c}\pm0.03$	$8.74^{b}\pm0.02$	$8.84^{a}\pm0.03$
Crude Protein (%)	$31.54^{a}\pm0.01$	$30.04^{g}\pm0.02$	$29.10^{h}\pm0.10$	$28.86^{i}\pm0.00$
ASH (%)	$3.17^{a}\pm0.23$	$2.71^{d}\pm0.02$	$2.65^{de}\pm0.00$	$2.51^{e}\pm0.06$
Crude fibre (%)	$0.94^{a}\pm0.01$	$0.86^{bc}\pm0.01$	$0.84^{c}\pm0.00$	$0.62^{d}\pm0.03$
Crude fat (%)	$8.82^{b}\pm0.03$	$7.74^{c}\pm0.01$	$7.74^{c}\pm0.00$	$6.97^{d}\pm0.02$
Carbohydrate (%)	$47.36^{h}\pm0.11$	$49.97^{f}\pm0.04$	$51.33^{b}\pm0.01$	$52.15^{a}\pm0.02$
Total energy value(KJ/g)	$1635.06^{c}\pm2.31$	$1616.31^{d}\pm0.58$	$1611.98^{e}\pm1.16$	$1605.74^{f}\pm1.73$
Dry Matter (%)	$91.75^{d}\pm0.03$	$91.35^{de}\pm0.02$	$91.26^{d}\pm0.02$	$91.15^{e}\pm0.02$

The crude fat content of raw seeds of *Canavalia plagiosperma* (8.82%) (Table 2) were found to be higher when compared to certain common legumes such as *Cicer arietinum* (4.16%); *Vigna mungo* (0.45%); *Vigna radiata* (0.71%); *Vigna aconitifolia* (0.69%) and *Phaseolus vulgaris* (0.9%) (Belmer *et al*., 1999). *Canavalia ensiformis* (5.8%); *canavalia Cathartica* (1.3%); canavalia maritime (1.7%) and canavalia gladiata (7.84%) (Arun *et al*, 2004).

The crude fat content of 8.82% for raw *Canavalia plagiosperma* seed indicate that it is not an oil seed when compared to soya bean that has up to 23.1% fat content (potter and Hotchkiss, 1995). The crude fat content decreased with increased processing time (Table 2) which could possibly be as a result of leaching out of the fat into the cooking water as pointed out by Okaka *et al*., (1992).There was no significant difference ($p \geq 0.05$) between the crude fat content of 30, 40 minutes cooking.

The carbohydrate content of raw *Canavalia plagiosperma* seed (47.36%) and that of the cooked samples are shown in Table 2. The processing treatment(cooking) had significant effects on the carbohydrate content of the seed.The carbohydrate content (47.36%) of raw *Canavalia plagiosperm*a is lower than that of most legume like *Bambara groundnut* (65%), broad bean (56.9%), chick peas (60.9%) etc (Okaka, 1997) Canavalia *cathartica* (52.8%), *Canavalia* maritima (50.5%), *Canavalia ensiformis* (53.86%) and *Canavalia gladiata* (61.15%). Its value (47.36%) was also higher than that of soya beans (32%), groundnut (21.0%) etc. (Okaka, 1997). On the other hand, the carbohydrate content (47.36%) of C. *plagiosperma* is lower than that of most cereals such as Millet (75-85%).Rice (80%), Guinea corn (68-80%), maize (65-84%) and wheat (65-75%) (Okaka, 1997).

ISSN 2056-5798(Print), ISSN 2056-5801(online)

The energy value (1635.06 kJ/g) of *Canavalia plagiosperma* raw seed was higher than that of some legumes like *Canavalia cathertica* (1520.0kJ/g), *Canavalia maritime* (1586.0kJ/g), *Canavalia ensiformis* (1632kJ/g) (Arun *et al*., 2004), *Mucuna pruriens Var*. *utilis* (1541.0kJ/g)(Vadivel and pugalenthi, 2007). The energy values were dependent on the metabolic fuels which are protein, carbohydrate and fat, since it was computed from them. There was significant different ($p \leq 0.05$) on the energy level of cooked samples.

There was significant difference ($P \leq 0.05$) on the dry matter level of 40 and 50 minutes cooked samples, and there was no significant different ($P \geq 0.05$) on 30 minutes cooked sample.

Effect of autoclaving on the anti-nutritional factors in *Canavalia Plagiosperma* Seed

In this work, there were general decreases in the levels of all the anti-nutritional factors determined as the level of heat processing increased (autoclaved)

Autoclaving caused a significant decrease in the tannin contents of Canavalia plagiosperma seed samples (Table 2). The highest reduction was caused by 35 minutes autoclaving. The increased reduction of tannins as time of autoclaving increases is mainly due to the fact that those compounds in addition to their predominance in seed coats (Reddy and Pierson, 1994), are water soluble (Kumar et al., 1979), and consequently leach into the liquid medium. This decrease could also be related to the fact that these compounds are heat labile (Rakic et al; 2007, Udensi *et al*.,) and degrade upon heat treatment. These results agree with those of Mubarack (2005) who found out that tannin content of mung bean seeds (Phaseolus aureus L) was reduced after autoclaving at $121^{O}C$ for 35 minutes. The effects of Tannin include interference with the digestive processes either by binding enzymes or by binding to food components like proteins or minerals (Elkin and Roger, 1990; Hagerman *et al*., 1992). Tannin also has the ability to form a complex with vitamin B_{12} and makes it unavailable (Liener 1980; Francis *et al*, 2001). They are also known to interact with other anti-nutrients.

Fish and Thompson (1991) reported the inhibitory action of tannins on amylase, by interaction between tannins and lectin, also, interaction between tannins and cyanogenic glucoside reduced the deleterious effect of the later (Goldstein and Spencers, 1985).

Table 2 shows the trypsin inhibitor content of raw and processed (autoclaved) seeds of *Canavalia plagiosperma*. Trypsin inhibitor activity (TIA) was significantly reduced by autoclaving. 35 minutes autoclaving reduced TIA by 87.60%. The data agree with findings by Kapoor and Gupta,(1978), Carlini and Udedibie, (1997) in other legumes.

The effect of processing treatments (autoclaving) on the phytic acid content of *Canavalia plagiosperma* seed is shown in Table 2. Autoclaving significantly reduced the phytic acid content of the seed. There were significant differences among the autoclaved samples. As the processing time increased, the level of phytic acid reduced. This is in agreement with the work of Hossain and

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Jauncey, (1990) who reported reduction of phytic acid in Linseed and Sesame seed meal by up to 72 to 74% respectively. 35 minutes autoclaving reduced the phytic acid level by 94.19% and was the most effective autoclaving time for phytic acid reduction. This is in accordance with the work of Kessler et al., (1990) who reported that autoclaving of jackbeans (*Canavalia ensiformis*) was a satisfactory technique for ensuring survival of birds receiving jackbean diets which confirmed the findings of Jayne-Williams (1973) and D' Mello *et al.*, (1985).

The observed reduction in phytic acid content of legume seeds during heat treatment may be partly due to the heat labile nature of phytic acid and the formation of insoluble complexes between phytate and other components (Udensi *et al*., 2007.Phytates can reduce bioavailability of minerals; impaired protein digestibility caused by formation of phytate- protein complexes and depressed absorption of nutrients due to damage to the pyloric caeca region of the intestine (Francis *et al*., 2001).

Table 3: Effect of autoclaving on the anti-nutritional factors in *Canavalia Plagiosperma* Seed

Sample	Tannin (%)	Trypsin Inhibitor (Tu/g)	Phytic acid (%)	Saponin (%)	Oxalate (%) (%)	phenol	Phenol (%)
Raw Seed	1.02[a] ±0.01	11.53[a] ±0.02	3.15[a] ±0.03	2.45[a] ±0.00	1.48[a] ±0.02	0.34[a] ±0.02	0.34[a] ±0.02
25 min Autoclaved	0.23[f] ±0.01	2.52[e] ±0.02	0.35[f] ±0.01	0.24[f] ±0.01	0.56[d] ±0.01	0.15[d] ±0.02	0.15[d] ±0.02
30 min Autoclaved	0.17[g] ±0.02	2.21f ±0.05	0.24[h] ±0.01	0.16[h] ±0.00	0.42[f] ±0.01	0.08[e] ±0.00	0.08[e] ±0.00
35 min Autoclaved	0.15[h] ±0.01	1.43[g] ±0.01	0.18[I] ±0.01	0.11[I] ±0.01	0.32[g] ±0.04	0.03[S] 0.01	0.03[g] ±0.01

There was significant decreasing effect ($p \leq 0.05$) on the saponin content of all the autoclaved samples (Table 1). 35 minutes autoclaving reduced the saponin content by 95.51%.Francis *et al*; (2001) recommended moist heat treatment because of high solubility of most saponin in water; aqueous extraction would remove most saponins from feed ingredients. The anti-nutritional effects of saponins include increased permeability of small intestinal mucosa cells thereby inhibiting nutrient transport. Other properties of saponin may play a role in its growth depressing action. Endogenous saponins have been found to reduce protein digestibility of soybean by Chymotrypsin (Shimoyamada *et al*., 1998), probably by the formation of sparingly digestible saponin- protein complexes (Potter *et al*., 1993). Complex formation between saponins and other anti-nutrients as reported by Makkar *et al*., (1995a) could lead to inactivation of the toxic effect of both substances. This is considered to be due to chemical reactions between them, leading to the formation of tannin-saponin complexes thereby inactivating the biological activity of both tannins and saponins.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

A Similar trend of result as above was observed with respect to oxalate contents of *Canavalia plagiosperma* seed meal which agrees with the work of Ugwu and Oranye (2006), Jimoh *et al*., (2011), and Olajide *et al*., (2011). Oxalates bind with calcium and magnesium, and interefere with their metabolism, cause muscular weakness and paralysis (Soetan and Oyewole, 2009).

The raw seed of *Canavalia plagiosperma* was found to contain phenol level of 0.38% which was reduced by the processing treatment (autoclaving). The treatments rendered to *Canavalia plagiosperma* reduced the total phenol level significantly but 35 minutes autoclaving showed the highest reduction effect.

Effect of cooking on the anti-nutritional factors in *Canavalia Plagiosperma* Seed

The effect of cooking on the anti-nutritional factors in *Canavalia plagiosperma* seed are presented in Table 4 above.

Six anti-nutrients were determined and the different levels at which they were found in the raw Seed of *Canavalia plagiosperma* were as follows; saponin (2.45%), phytic acid (3.15%), Tannin (1.02%), oxalate (1.48%), phenol (0.34%), Trypsin inhibitor (11.53 Tiu/g).

In this work, there were general decreases in the levels of all the anti-nutritional factors determined as the level of heat processing (cooking) increased.

Cooking caused a significant decrease in the tannin contents of *Canavalia plagiosperma* seed samples (Table 4). The highest reduction was caused by 50 minutes cooking (boiling)(1.02-0.14%), The increased reduction of tannins after cooking (boiling) is mainly due to the fact that those compounds in addition to their predominance in seed coats (Reddy and Pierson, 1994), are water soluble (Kumar et al., 1979), and consequently leach into the liquid medium. This decrease could also be related to the fact that these compounds are heat labile (Rakic et al; 2007, Udensi *et al*., 2007) and degrade upon heat treatment. These results agree with those of Mubarack (2005) who found out that tannin content of mung bean seeds (Phaseolus aureus L) was reduced after boiling (cooking) in tap water for 90 minutes, autoclaving at 121^{O}C for 35 minutes, microwave cooking for 15 minutes and soaking for 12h respectively.

These results are also in harmony with those of Rehman and Shah (2005) who stated that tannin content of black kidney bean, red kidney bean and white kidney bean were significantly reduced after ordinary cooking and pressure cooking at 121^{O}C for 20 minutes respectively.

Table 4 shows the effect of cooking on trypsin inhibitor of *Canavalia plagiosperma* seed samples. Trypsin inhibitor activity (TIA) was significantly reduced by cooking. 50 minutes cooking (boiling) reduced the TIA from (11.53- 0.23%). From Table 4, 50 minutes cooking reduced the TIA by 98.01%, being the most effective. This finding agree with that of Marquez and Alonso, (1999) who reported a reduction in trypsin inhibitor level during soaking and cooking (boiling) of chickpea.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Similarly, kadam and smithard, (1987) also observed a significant decrease in the TIA of winged bean after cooking of presoaked bean. Devaraj and Manjunath, (1995) found that the *Doliclios lablab* proteinase inhibitors activity was completely lost by 60 minutes cooking. Cooking for 60 minutes at 100^{O}C was sufficient to inactive over 90% of TIA in *phaseolus vulgaris* (Trugo *et al*., 1990).

The effect of cooking on the phytic acid content of *Canavalia plagiosperma* seed is shown in Table 4. Cooking significantly reduced the phytic acid content of the seed. There were significant differences among the cooked and roasting. As the processing time increased, the level of phytic acid reduced. This is in agreement with the work of Hossain and Jauncey, (1990) who reported reduction of phytic acid in Linseed and Sesame seed meal by up to 72 to 74% respectively.

The observed reduction in phytic acid content of legume seeds during heat treatment may be partly due to the heat labile nature of phytic acid and the formation of insoluble complexes between phytate and other components (Udensi *et al*., 2007). Khattab and Arntfield (2009) reported that in cooking, phytic acid combines with the calcium and Magnesium in the seed to form insoluble calcium and magnesium phytates

Table 4: Effect of cooking on the anti-nutritional factors in *Canavalia Plagiosperma* Seed

Sample	Tannin (%)	Trypsin Inhibitor (Tu/g)	Phytic acid (%)	Saponin (%)	Oxalate (%)	phenol (%)	Phenol (%)
Raw Seed	**1.02^{a}**	**11.53^{a}**	**3.15^{a}**	**2.45^{a}**	**1.48^{a}**	**0.34^{a}**	**0.34^{a}**
	±0.01	**±0.02**	**±0.03**	**±0.00**	**±0.02**	**±0.02**	**±0.02**
30 min Cooked	**0.28^{e}**	**1.41^{e}**	**0.39^{e}**	**0.26^{e}**	**0.15^{d}**	**0.15^{d}**	**0.15^{d}**
	±0.01	**±0.01**	**±0.01**	**±0.00**	**±0.00**	**±0.00**	**±0.02**
40 min Cooked	**0.22^{f}**	**1.37^{h}**	**0.27^{g}**	**0.19^{g}**	**0.07^{ef}**	**0.07^{e}**	**0.08^{e}**
	±0.01	**±0.00**	**±0.01**	**±0.01**	**±0.01**	**±0.01**	**±0.00**
50 min Cooked	**0.14^{hi}**	**0.23^{I}**	**0.24^{h}**	**0.09^{J}**	**0.04^{fg}**	**0.04^{fg}**	**0.03^{g}**
	±0.01	**±0.05**	**±0.01**	**±0.01**	**±0.00**	**±0.00**	**±0.01**

.

There was significant decreasing effect ($p \leq 0.05$) on the saponin content of the entire cooked samples. Cooking reduced saponin by 96.33% .Francis *et al*; (2001) recommended moist heat treatment because of high solubility of most saponin in water; aqueous extraction would remove most saponin from feed ingredients. The anti-nutritional effects of saponins include increased permeability of small intestinal mucosa cells thereby inhibiting nutrient transport. Other properties of saponin may play a role in its growth depressing action (Potter *et al*., 1993).

Oxalate contents of Canavalia *plagiosperma* seed meal increased as the cooking time increased which agrees with the work of Ugwu and Oranye (2006), Jimoh *et al*., (2011), and Olajide *et al*., (2011). Oxalates bind with calcium and magnesium, and interfere with their metabolism, cause muscular weakness and paralysis (Soetan and Oyewole, 2009). The raw seed of *Canavalia plagiosperma* was found to contain phenol level of 0.38% which was significantly reduced by

ISSN 2056-5798(Print), ISSN 2056-5801(online)

cooking. 50 minutes cooking was more efficient in the reduction of phenol in the *Canavalia plagiosperma* piper seed.

CONCLUSION AND RECOMMENDATIONS

The results from the proximate composition of the raw *Canavalia plagiosperma* (oblique-seeded Jack bean) revealed its good nutrient potentials (high protein, carbohydrate, ash and total energy contents) which is suggesting that it could be used in food formulations such as; substituting other legumes in traditional dishes like 'akara', 'moi-moi', peanut, etc for both the young and old people thereby diversifying diets. The seed cannot serve as a good source of fibre for mankind and roughage for animals, also, from the level of fat content of the seed, it is discovered that C. *Plagiosperma* seed cannot be regarded as an oil seed. The result of anti- nutritional factors revealed that moist heat treatment (autoclaving and cooking) are good in reducing anti- nutrients. The two treatments drastically reduced the level of anti-nutritional factors; both autoclaving and cooking reduced it to the level that is safe for human consumption. The seed can be used as a good plant protein source for this teaming population in the world since animal protein is very expensive. It could also be used to fortify cereal based diets such as pap. Looking at the protein and carbohydrate content of the seed, it is suggested that the processed seed could be helpful in reducing nutritional related problems (such as protein-calorie malnutrition) in Africa. The processing treatments used in this work caused reduction at different rates in the level of anti-nutrients present in the raw seed of *C. plagiosperma* to tolerable level safe for consumption; it is therefore recommended that slightly increasing the processing time may totally eliminate the anti-nutrients in the seed.

REFERENCES

A.O.A.C. (1990) Official Methods of Analysis. Association of Official Analytical Chemists (15th ed.) Vol. 2 Associate of Official Chemistry, Arlington, Virginia, U.S.A.

A.O.A.C. (2000) Official methods of analysis 17th edn.Association of Official Analysis Chemist (A.O.A.C) International, Gaithersburg, M.D.

Akinmutimi, A.H., Abasiekong, S.F. and Izundu, R.O. (2002) Effect of Processing on metabolisability of energy and protein content of sword bean (*Canavalia gladiata)* using Muscovy ducks (*Carina Muschata*) *Tropical Journal of Animal Science*, 5:51 – 56.

Akinmutimi, A.H. (2004) Evaluation of Sword bean (*Canavalia gladiata*) as an alternative feed resources for broiler chickens. PhD Thesis Department of Non-ruminant animal production, Micheal Okpara University of Agriculture Umudike, Nigeria.

Aruah, B.C, Uguru, M.I, and Oyiga, B.C (2012) Genetic variability and interrelationship among some Nigerian pumpkin accessions (*Curcurbitassp*).Plant Breeding. Int. J. (6): 34-41.

Arun, A.A., Sridhar, K.R., Raviraja, N.S., Schmidt, E. and Jung, K. (2004) Nutritional and anti-nutritional components of *Canavalia spp* Seeds from the West Coast Sand dunes of India, Plant Food for Human Nutrition 58:1-13.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Belmer, R., Nava – Montero, R., Sandoval – Castero, C. and Mc-Nab, J.M. (1999). Jack bean (*Canavalia ensiformis* L. Dc) in poultry diets, anti-nutritional factors and detoxification studies. *A review world poultry science Journal* 55: 37-59.

Carlini, C.R. and Udedibie, A.B.I. (1997) Comparative effect of processing methods of haemagglutinating and anti-trypsin activities of *Canavalia Braziliensis* Seeds. *Journal of Agriculture, Food and Chemistry* 45: 4372 – 4377.

Costa, G.E.A., Queiroz – Monici, K.S., Machado – Reis, S.M.D. and Oliveira, A.C. (2006) Chemical Composition, dietary fibre and resistant starch content of raw and cooked pea, common bean, chickpea and lentil legumes.

D' Mello, J. P.F., Acamovic, T. and Walker, A.G. (1985) Nutritive value of Jack bean (*Canavalia ensiformis L. Dc*) Tropical Agriculture. (Trinidad), 65: 376 – 377.

Devaraj, V.R. and Manjunath, N.H. (1995) Effects of Cooking on Proteinase inhibitors of Dolichos Lablab bean (*Dolichos Lablab Prepureus*). Plant Food, Human Nutrition 48: 107-112.

Effiong, G.S., Ibia, I.O. and Udofia, U.S (2009) Nutritive and energy values of some wild fruit spices in Southeastern Nigeria.Electronic Journal of Environment, Agriculture and food chemistry.8(10);917-923.

Elkin, R.G. and Rogler, J.C. (1990) Comparative effects of dietary tannins in ducks, chicks and rats. Poultry Science 69(10): 1685 – 1693.

Enwereuzoh, R.O., Okafor, D.C., Uzoukwu, A.E., Ukanwoke, M.O., Nwakaudu, A.A and Uyanwa, C.N (2015) Flavour extraction from *Monodora myristica* and *Tetrapleura tetraptera* and production of flavoured popcorn from the extract. European Journal of Food Science and Technology. Vol.3,no 2, p1.17

Esonu, B.O. (2009) Unconventional Feed resource for Livestock development and food security, paradigms from Nigerian livestock Industry. 14th Inaugural Lecture of Federal University of Technology, Owerri, Imo State, Nigeria. Delivered on Wednesday 24th of June, 2009.

Esonu, B.O., Anumni, P.E., Udedibie, A.B.I., Emenalom, O.O., Etuk, B., Odoemelam, V. and Okorie, K.C. (2013) Evaluation of Two- Stage cooked *Canavalia plagiosperma* (*piper*) seed meal as feed ingredient in layer Diets. Nigerian journal of Animal Science 15: 95-103.

Ezegbe, C.C. (2012) Nutritional quality and physico- Chemical properties of the seed and oil of Chinese Fan Palm. MSc Thesis, Department of Food Science and Technology, Federal University of Technology Owerri, Nigeria.

Fish, B.C. and Thompson, L.U. (1991) Lectin – tannin interactions and their influence on pancreatic amylase activity and starch digestibility. *Journal of Agriculture and food Chemistry* 39: 727 – 731.

Francis, G., Makkar, H. P.S. and Becker, R. (2001) Anti-nutritional factors present in plant derived alternative fish feed ingredients and their effects in fish feed ingredients and their effects in fish. Aquaculture 199: 197 – 227.

Geervani, P. and Theophilus, F. (1980) Effect of home processing on the protein quality of selected legumes. *Journal of Food Science* 45:707-710.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Gliadge, P.N., Shewalker, S.V. and Wan Khede. (2008) Effect of Processing Methods on qualities of instant whole legume pigeon pea (*Cajanus cajana*) Agriculture Engineering International. The IGRE Journal Manuscript FP 004. Vol. X.

Goldstein, W.S. and Spencer, K.C. (1985) Inhibition of Cyano-genesis by tannin. *Journal of Chem. Ecol*. 11:847-857.

Hagarman, A.E., Robbin, C.T., Weerasuriya, Y., Wilson, T.C. and Mc Arthur, C. (1992) Tannin Chemistry in relation to digestion. *Journal of Range Management* (USA) 45(1): 57-62.

Hossain, M.A. and Jauncey, K. (1990) Detoxification of Oil Seed and Sesame meal and evaluation of this nutritive value in the diets of common Carp (*Cyprinus carplo* L) Asian Fisheries Science. Pp 169-183.

Jayne – William, D.J. (1973) The influence of dietary Jack bean (*Canavalia ensiformis*) and Concanavalin A On the growth of Conventional and gnotobiotic Japanese quail (*Coturnix coturnix japonica*). Nature, New Biology 243: 150 – 151.

Kadam, S.S. and Smithard, R.R. (1987) Effect of heat treatment on trypsin and haemagglutinating activities in winged bean. Plant foods. Human Nutrition 48: 107-112.

Kapoor, A.C. and Gupta, V.P. (1978) Trypsin inhibitor activity in soybean seeds as influenced by stage of its development and different treatments and the distribution of its anatomical parts. *Indian Journal of Nutrition and Dietics* 15: 429-433.

Kessler, M., Belmar, R. and Ellis, N. (1990) Effects of Autoclaving on the Nutritive value of seeds of *Canavalia ensiformis* (Jack beans) for Chicks. Tropical Agriculture (Trinidad), 67: 166 - 120.

Khattab, R.V. and Amtfield, S.D. (2009) Nutritional quality of legume seeds as affected by some physical treatments. *Journal of Food Science and Technology* 42: 113 – 118.

Kumar, N.R., Reedy, A.N. and Rao, K.N. (1979) level of Phenolic Substances on the leachionted in *Cicezo* seed. *Journal of Experimental Biology* 17; 114 – 116.

Lienel, H.H (2002). Ash analysis, in introduction to chemical analysis of foods, Nielsen, S.S (edn).p. 123-133. CBS PUBLISHERS, New Delhi.

Liener, I.E. (1980) Heat labile anti-nutritional factors. In: Advances in Legumes Sciences (Eds. Summerfield, R.J. and Bunting, A.H). Kew, London, Royal Botanic Gardens, Pp: 157 – 170.

Makkar, H. P.S., Blummel, M. and Becker, K. (1995a) In Vitro effects and interactions between tannins and saponins and fate of tannins in the rumen. *Journal of Science, Food Agriculture* 69: 481-493.

Marquez, M.C. and Alonso, R. (1999) Inactivation of trypsin inhibitor in Chickpea. *Journal of Food Composition Analysis* 12: 211 – 217.

Moreina, R.A., Cordeiro, E.F., Cavada, B.S., Nunes, E.D., Fernerndes, A.G. and Oliveine, J.T.A. (1993) Plant Seed Lectins. A possible marker for Chemotaxonomy of the qenus *Canavalia*. R. Bras. Veg. Brazil Pp 127-132.

Mubarak, A.E. (2005) Nutritioal Composition and Anti-nutritional factors of Mung bean seeds. (*Phaseolus* guneus) as affected by some home traditional processes. Food Chemistry 89: 489-495.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Nwosu, J.N. (2011) The effects of processing on the anti-nutritional properties of 'Oze' (*Bosqueia angolensis*) Seed. *Journal of American Science* 7(1): 1-6.

Odoemelam, V.U. (2007) Proximate Composition, anti-nutritional properties and mineral assay of raw and processed *Canavalia plagiosperma* seed. M.Sc. Thesis, Department of Animal Production and Management, Micheal Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Okaka, J.C., Akobundu, E.N.T. and Okaka, A.N.C. (1992) Human Nutrition: An Integrated approach (2nd ed.) OcJanco Academic publishers, Enugu. Pp. 355-375.

Okaka, J.C. (1997) Cereals and Legumes: Storage and Processing Technology. Data and Microsystems Publishers, Ogui, Enugu, Nigeria. Pp. 12 -14, 29-30.

Olajide, R., Akinsoyinu, A.O., Babayemi, O.J., Omojola, A.B., Abu, A.O. and Afolabi, K.D. (2011) Effect of Processing on Energy values, nutrient and anti-nutrient components of wild Cocoyam (*Colocassia esculenta L. Schott*) Corm. *Pakistan Journal of Nutrition.* 10(1): 29-34.

Onuh, M.O. and Igwemma, A.A. (2000) Applied Statistical techniques for Business and Basic Sciences. Skillmark Media Ltd. Owerri, Imo State. Pp. 176 – 190, 205 – 215, 322-338.

Potter, N.N. and Hotchkiss, J.H. (1995) Food Science (5th ed.) CBS Publishers and distributors, New Delhi. Pp. 359 – 368, 402 – 408, 577 – 591.

Potter, S.M., Jimenez – Fores, R., Pollack, J. Pollack, J., Lone, T.A. and Berber – Jimenez, M.D. (1993) Protein – Saponin interaction and its influence on blood lipids. *Journal of Agriculture and Food Chemistry* 41: 1287-1291.

Pugalenthi, M., Vadivel, V. and Janak, P. (2007) Comparative evaluation of protein quality of raw and differentially processed seeds of an underutilized food legumes, (*Abrus precatorius* L) livestock Research for Rural Development Article No. 168. Available in the online website. http://www.lrrd.Org/lrrd19/11/puga19168.htm.

Rakic. S., Petrovic, S., Kukic, J., Jadranin, M., Tesevic, V. and Povrenovic, D. (2007) Influence of thermal treatment on phenolic compounds and antioxidant properties of Oak acorns from Serbia. Food Chemistry. 104: 830 – 834.

Reedy, N.R. and Pierson, M.D. (1994). Reduction in anti-nutritional and toxic components in plant foods by fermentation. Food Research International 27: 281 – 290.

Rehman, Z. and Shah, W.H. (2005). Thermal heat processing effects on anti- nutrients, protein and starch digestibility of food legumes. Food chemistry 19:327-331.

Shimoyamada, M., Ikedo, S., OOtsubo, R. and Watanabe, K. (1998) Effects of soybean saponin on chymotryptic hydrolyses of soybean proteins. *Journal of Agriculture and Food Chemistry* 46 (12) 4793 – 4797.

Soetan, K.O. and Oyewole, O. E. (2009) The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds. *A review, African Journal of Food Science* 3(9): 223-231.

Trugo, L.C. Ramos, L.A. and Souza, M.C.P (1990) Oligosaccharide composition and trypsin inhibitor activity of *Phaseolus vulgaris* and the effect of germination on the alpha galactoside composition and fermentation in the human colon. Food Chemistry 36: 53 – 61.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Udedibie, A.B.I., Esonu, B.O. and Agbabiaka, L.A. (2000) Comparative performance of broilers fed diets containing differentially processed Jack bean meals. NPSJ. I: 32 – 41.

Udensi, E.A., Ekwu, F.C. and Isinguzo, J.N. (2007). Anti-nutritional factors in vegetable cowpea (*Sesquipedalis*) seed during thermal processing. *Pakistan Journal of Nutrition* 6: 194 -197.

Ugwu, F.M. and Oranye, N.A. (2006) Effects of some processing methods on the toxic components of African bread fruit (*Treculia africana*). *African Journal of Biotechnology* 5 (22): 2329 – 2333.

Vadivel, V. Pugalenthi, M. and Megha, M. (2008) Biological evaluation of protein quality of raw and processed seeds of gila bean (*Entada scandens benth.*) J. Trop. Sub Strop. Agroecosystems 8: 125 – 133.

ISSN 2056-5798(Print), ISSN 2056-5801(online)