

## Full Length Research Paper

# Effect of processing methods on the nutritional values and anti-nutritive factors of *Adenanthera pavonina* L. (Fabaceae) seeds

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This research aimed at determining the effect of processing on the nutritional and anti-nutritional values of “food tree” [*Adenanthera pavonina* L. (Fabaceae)] seeds, a highly nutritional and underutilized legume. The seeds were separated into three groups namely, boiled, roasted and raw. Quantitative analysis was carried out to measure their proximate, minerals, vitamins and anti-nutrients compositions. Analysis of variance was used to analyze the treatment groups and Duncan’s multiple range tests to determine significant difference at  $P \leq 0.05$ . The results show that processing significantly affected the nutritional and anti-nutritional constituents. The values for proximate composition in the raw, roasted and boiled seeds were: proteins (15.79±0.04, 18.86±0.02 and 23.25±0.02, respectively), carbohydrates (56.60±0.02, 54.89±0.02 and 52.05±0.02 respectively), fat (9.78±0.02, 11.70±0.02 and 11.40±0.02, respectively), crude fibre (9.80±0.04, 9.70±0.04 and 5.85±0.02, respectively), moisture (3.88±0.03, 0.10±0.02 and 3.20±0.02, respectively) and ash (4.03±0.01, 4.75±0.02 and 4.25±0.01, respectively). The values for mineral compositions in the raw, roasted and boiled seeds were: calcium (25.61±0.34, 30.34±0.02 and 80.88±0.02, respectively), magnesium (18.97±0.01, 22.76±0.01 and 60.68±0.02, respectively), phosphorus (7.00±0.06, 6.40±0.15 and 5.80±0.10, respectively), potassium (3.31±0.00, 2.43±0.02 and 4.23±0.02, respectively) and iron (0.41±0.02, 0.41±0.01 and 1.23±0.01, respectively). The values for vitamin compositions in the raw, roasted and boiled seeds were:  $\beta$  carotene (1458.33±0.01, 416.67±1.20 and 416.67±0.08, respectively) and vitamin E (22.50±0.02, 9.24±0.02 and 12.69±0.01, respectively). The mean values for anti-nutrient compositions in the raw, roasted and boiled seeds were: tannin (1.21±0.00, 0.049±0.00 and 0.15±0.00, respectively), phytate (5.16±0.02, 3.50±0.01 and 1.50±0.02, respectively), oxalate (0.34±0.00, 0.13±0.00 and 0.11±0.00, respectively), cyanide (1.17±0.00, 0.95±0.00 and 0.32±0.00, respectively) and trypsin inhibitor (0.92±0.01, 0.36±0.01 and 0.90±0.01, respectively). The results show that processing changed the nutritional constituents and reduced the anti-nutrients in the seeds of *A. pavonina* and boiling proven to be the best processing method.

**Key words:** Processing, techniques, nutritional, anti-nutritive, *Adenanthera pavonina*, seeds.

## INTRODUCTION

Food legumes constitute a major source of nutrients such as proteins, lipids, carbohydrates, and other important

substances such as fibre, minerals and vitamins (Deshpande, 1992) which are necessary for human and animal health. Similarly, they contain anti-nutritional components such as saponins, tannins, phytates, lectin/haemagglutinin, oxalates, polyphenol, among others, which hinder the body from digesting the nutrients in pulses. These toxins cause food poisoning to human beings and animals (Osifo, 1974). According to Olusanya (2008) and Geil and Anderson (1994), legumes contain some toxic components such as anti-trypsin factors which impair the digestion of proteins and hence prevent its efficient utilization. Phytates, oxalates and cyanides cause various physiological disorders like increase in relative weight of pancreas and liver, and also diarrhea (Arija et al., 2006). Fortunately, many of these toxic components are destroyed by heat provided by different food processing methods (Olusanya, 2008).

Boiling and roasting are important household food processing methods. Boiling is a method of cooking food in water such that it bubbles vigorously, while roasting is achieved in an uncovered pan without water to produce a well-browned exterior and a moister cooked interior. These processing treatments increase the nutritional quality of food plants and are also effective in eliminating the anti-nutritional factors in them and thus the need for their proper processing to levels where they are safe for human and animal consumption (Hotz and Gibson, 2007; Nzewi and Egbuonu, 2011).

*Adenanthera Pavonina* L. (Fabaceae) is a woody Southeast Asian species of legume mostly known for its edible seeds (Arzumand et al., 2010). It is endemic to India and Southeast China, where it is considered as an alternative nutrients source for animals and humans, but has been introduced into tropical and sub-tropical areas of the world including Malaysia, Polynesia and eastern and West Africa. The plant is known as "food tree" because its seeds and leaves are valued for food, and the seeds, which when roasted are said to taste like soy bean, possess high percentage of proteins, fatty acids, minerals and other nourishing properties (Olajide et al., 2004; Senga et al., 2013).

It has been used in traditional medicine practices to treat many diseases such as asthma, boil, diarrhoea, gout, inflammations, rheumatism, tumor and ulcers, and as a tonic (Ghani, 2003; Arzumand et al., 2010). Several parts of the plant have been verified for its medicinal importance hence, the bark and leaves are used in the treatment of gonorrhoea, ulcers and rheumatism. The powdered seeds are applied as a poultice to abscess and to promote suppuration (Hussain et al., 2010; Sujit et al., 2010). Physicochemical characterization of the seed oil showed appreciable amounts of neutral lipids and unsaturated fatty acids including linoleic, oleic and

lignoceric acids (Robert et al., 2004). However, report on its antinutritive constituents is totally lacking.

In Nigeria and other parts of West African where it has been introduced, the tree has been economically utilized as source of timber and wood fuel. However, there is no report on utilizing any part of it, including the seeds as food. Therefore, the present research was to analyze the nutritional potentials of the seeds in combating malnutrition and food insecurity.

## MATERIALS AND METHODS

### Source of plant material

Dried pods of *A. pavonina* L. were obtained from the Botanic Garden, Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Enugu State in May, 2016. The seeds were separated from the dried pods, cleaned and freed from foreign matters and air dried. The dried seeds were stored in air-tight bottles for further studies.

### Preparation of samples

The preparation of the various sample groups was done following the methods of Ajeigbe et al. (2012).

### Boiling

Whole seeds (100 g) were weighed using digital weighing balance and soaked in distilled water for overnight. The soaked seeds were boiled for 1 h and then rinsed with distilled water. Further boiling was done for another 2 h before the seeds were dried using Gallenkamp hot air oven at 40°C for 15 min.

### Roasting

With the aid of a digital weighing balance, 100 g whole seeds were weighed and roasted in Gallenkamp hot air oven at 120°C for 1 h. The roasted seeds were allowed to cool.

### Raw sample

Raw processing was done by drying 100 g whole seeds in hot air oven at 40°C. The prepared samples were separately ground with Thomas hammer mill blender to obtain powdered particle size of 1 mm. The powdered samples were stored in air-tight bottles at room temperature for further analysis.

### Nutritive analysis

#### Determination of proximate composition of seed samples

The proximate composition of the samples was done following the standard methods as recommended by Pearson (1976) and the Association of Official Analytical Chemists (AOAC, 1990).

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**Crude protein**

The crude protein content of foods or plant sample was determined by using the Micro Kjeldahl Nitrogen Method (Pearson, 1976). The method involves digestion of samples, distillation of digests and titration of distillate.

**Crude fat (using Soxhlet apparatus)**

Two grammes aliquot of the processed sample was weighed into a 250 ml clean flask and put into the thimble. The boiling flask was filled with 250 ml n-hexane. The Soxhlet apparatus was set and refluxed for about 3 h. The thimble was removed with care and the hexane was collected in the top container of the set up and drained into a container for re-use. When the flask was almost free of hexane, it was removed and dried at 105°C to a constant weight. It was transferred from the oven into a desiccator and allowed to cool, and then weighed.

**Fibre**

Two grammes aliquot of the sample was weighed and 150 ml of heated H<sub>2</sub>SO<sub>4</sub> was added and heated to boiling for 30 min and filtered. The residue was washed three times with hot water. Pre-heated KOH (150 ml) was added and the residue was heated to boiling. Few drops of anti-foaming agent were added and boiled slowly for 30 min. The residue was filtered and washed three times with hot water, then washed with acetone, dried at 130°C for 1 h and weighed.

**Moisture (using oven method)**

A crucible was thoroughly washed and dried in the oven, then cooled in a desiccator and weighed. Two grammes of the sample was weighed into the crucible. The crucible and the content was transferred into a hot air oven and dried at 105°C to a constant weight. The sample was then cooled in desiccator and the weight of the crucible and the content was taken, recorded and calculated.

**Ash (using muffle furnace)**

Two grammes aliquot of the sample was put into a weighed crucible and pre-ashed to drive off most of the smoke. The pre-ashed sample was transferred into a furnace at 550°C and allowed to ash until white ash was obtained. The desiccator was cooled and reweighed. Ash content was calculated.

**Carbohydrate**

Carbohydrate content was determined by the difference in the percentage composition of protein, crude fat, ash, moisture and crude fibre (AOAC, 1990).

**Determination of mineral composition****Calcium**

Calcium was determined using Pearson (1976) method. 25 ml of the sample was pipetted into a conical flask, a pinch of EBT was added, 2 ml of the NaOH solution was also added and the mixture was titrated with standard EDTA solution.

$$\text{Ca (mg/100 g)} = \frac{T \times N \times E \times 1000}{\text{Volume of sample used}}$$

Where, T = Titre value; M= molarity of EDTA; E = equivalent weight of calcium.

**Magnesium**

Magnesium was determined using Pearson (1976) method. Aqueous extract of the sample (25 ml) was pipetted into a conical flask and a pinch of EBT was added and then shaken. This was followed by the addition of 2 ml buffer. The mixture was then titrated using 0.01 M EDTA.

$$\text{Mg (mg/100 g)} = \frac{T \times N \times E \times 1000}{\text{Volume of sample used}}$$

Where T = Titre value; M= molarity of the standardized EDTA; E = equivalent weight of magnesium.

**Phosphorus**

Phosphorus was determined using Pearson (1976) method. Aqueous extract of the sample (5 ml) was pipetted into a test tube and 5 ml of the molybdate solution was added and the absorbance read at 420 nm. The concentration was calculated using the standard curve.

**Potassium (using flame photometer)**

Potassium was determined using Pearson (1976) method. The instrument was switched on and allowed for about 20 min to stabilize. The gas was then turned on, distilled water was aspirated through the siphon in order to zero the instrument and the samples were aspirated and the emission recorded. The concentrations were calculated using sodium and potassium calibration curve for sodium and potassium readings, respectively.

**Iron**

Iron was determined using Pearson (1976) method. The sample (10 ml) was added into a 100 ml flask and made up to 50 ml with de-ionized water. Concentrated HCl (20 ml) was added followed by the addition of 1 ml of hydroxylamine solution. About 0.5 g glass beads was added and heated to boiling point till the volume reduced to 2 ml. Ammonium acetate buffer solution (10 ml) and 2 ml of phenanthroline were added and the content made up to 100 ml mark with de ionized water.

**Determination of vitamin composition****Vitamin A (β-carotene)**

One gram of the sample was weighed. Then, the proteins were first precipitated with 3 ml of absolute ethanol before the extraction of vitamin A with 5 ml of heptane. The test tube containing this was shaken vigorously for 5 min. On standing, 3 ml from the heptane layer was taken up in a curvette and read at 450 nm against a blank of heptane. The standard was prepared and read at 450 nm wavelength using UV/Vis spectrophotometer (Model: CE 2041), and vitamin A calculated from the standard (Pearson, 1976).

**Table 1.** Mean proximate constituents observed in raw and processed (roasted and boiled) seeds of *A. pavonina*.

| Sample  | Protein (%)              | Carbohydrate (%)        | Crude fat (%)           | Crude fibre (%)        | Moisture (%)           | Ash (%)                 |
|---------|--------------------------|-------------------------|-------------------------|------------------------|------------------------|-------------------------|
| Raw     | 15.79±0.004 <sup>a</sup> | 56.60±0.02 <sup>c</sup> | 9.78±0.02 <sup>a</sup>  | 9.80±0.04 <sup>b</sup> | 3.88±0.03 <sup>c</sup> | 4.03±0.019 <sup>a</sup> |
| Roasted | 18.86±0.02 <sup>b</sup>  | 54.89±0.02 <sup>b</sup> | 11.70±0.02 <sup>c</sup> | 9.70±0.04 <sup>b</sup> | 0.10±0.02 <sup>a</sup> | 4.75±0.02 <sup>c</sup>  |
| Boiled  | 23.25±0.02 <sup>c</sup>  | 52.05±0.02 <sup>a</sup> | 11.40±0.02 <sup>b</sup> | 5.85±0.02 <sup>a</sup> | 3.20±0.02 <sup>b</sup> | 4.25±0.01 <sup>b</sup>  |

Mean value with different superscript alphabets in each column are significantly different from each other by DMRT ( $P < 0.05$ ).

### Vitamin E

One gram of each sample was macerated with 20 ml of petroleum ether for 10 min. The macerated samples were allowed to stand for 1 h with intermittent shaking at every 10 min and thereafter, centrifuged for 5 min. Three millilitres of supernatant was transferred into triplicate test tubes, evaporated to dryness and then re-dissolved with 2 ml of ethanol and shaken. One millilitres of 0.2% ferric chloride in ethanol, 1 ml of 0.5% and dipyrindyl in ethanol and 1 ml of ethanol were added and the resultant solution was made up to 5 ml. The solution was mixed thoroughly by shaking and absorbance was taken at wavelength of 520 nm using UV/Vis spectrophotometer (Model: CE 2041), against the corresponding blank.

### Anti-nutritive analysis

#### Tannins

This was determined as described by Pearson (1976). Distilled water (10 ml) was added to 1 g of the test sample and shaken at 5 min interval for 30 min. The solution was centrifuged to get the extract. Two and half millilitre of the supernatant was transferred into a test tube and 2.5 ml of standard tannic acid solution was also transferred into a 50 ml flask. One millilitre Folin-Denis reagent was added into the flask, followed by 2.5 ml of saturated  $\text{Na}_2\text{CO}_3$  solution and the solution was made up to the mark. Absorbance was read after 90 min incubation at room temperature using UV/Vis spectrophotometer (Model: CE 2041).

#### Phytate

The sample (0.5 g) was extracted with 100 ml of 2.4% HCl for 1 h at room temperature. The extract (5 ml) was pipetted into a test tube and diluted with 25 ml of distilled water. 0.7 M sodium chloride (15 ml) was added and the absorbance was read at 520 nm using UV/Vis spectrophotometer (Model: CE 2041). The value was calculated from a prepared standard curve and blank (Pearson, 1976).

#### Oxalate

One gram of the powdered sample was weighed and put into a test tube and 47.5 ml of water and 2.5 ml of 6 N hydrogen chloride were added to the powdered sample. It was boiled for 1 h and made up to 62.5 ml with water. The solution was cooled at room temperature and filtered. Some filtrate (12.5 ml) was taken and the pH was adjusted to the range of 4.0 to 4.5 with dilute ammonia ( $\text{NH}_3$ ). The solution was heated up to 90°C, filtered and heated up again to 90°C. Then, 5 ml of calcium chloride was added to the solution with constant stirring. The solution was allowed to stand overnight. The solution was centrifuged for 5 min and the supernatants were decanted off. The precipitate was dissolved with 5 ml of 20%

sulphuric acid. It was heated until about to boil. The solution was then titrated with 0.5 N standard  $\text{KMnO}_4$  until a pale pink colour that persisted for 30 s was attained and the percentage oxalate was calculated (Pearson, 1976).

#### Cyanide

Five grams of the sample was prepared into a paste and the paste was dissolved in 50 ml of distilled water and allowed for the cyanide extraction to stay overnight, then filtered and the filtrate was used for the cyanide determination. To 1 ml of the sample filtrate in a test tube, 4 ml alkaline picric acid was added and allowed to stand for 5 min. The absorbance was read at 490 nm after colour development (reddish brown colour). The absorbances of the blank and standard were also read and the cyanide content of the test sample was extrapolated from cyanide standard (Pearson, 1976).

#### Protease inhibitor

Two grammes of the finely ground sample was extracted with 10 ml of 0.01 N NaOH for 1 h. 5 ml of benzoyl-DL arginine-p-nitro anilide hydrochloride (BAPNA) solution was hydrolyzed with 2 ml of 0.2 mg/ml trypsin (Sigma Type 11) in 0.0001 M HCl. P-nitro anilide was released as a coloured product and absorbance was read at 410 nm (Pearson, 1976).

#### Data analysis

The data obtained for the nutritive (proximate, mineral and vitamins) and anti-nutritive composition were statistically analyzed using one way analysis of variance (ANOVA) and reported as mean  $\pm$  standard error of triplicate data. Duncan's multiple range test was used for mean separation.

## RESULTS

Proximate compositions of the raw and processed (roasted and boiled) seeds of *A. pavonina* are presented in Table 1. The processed seeds had the highest values of protein, crude fat and ash while the raw seeds had more carbohydrate, crude fibre and moisture. The proximate composition also varied significantly ( $P < 0.05$ ) between the boiled and roasted seeds.

Analysis of variance (ANOVA) showed that there is significant difference ( $P < 0.05$ ) in the mineral composition of the processed (roasted and boiled) seeds of *A. pavonina* when compared with the raw seeds. Processing methods affected the composition of mineral

**Table 2.** Mean constituents of the mineral nutrients observed in raw and processed (boiled and roasted) seeds of *A. pavonina*.

| Sample  | Ca (mg/100 g)           | Mg (mg/100 g)           | P (mg/100 g)           | K (ppm)                | Fe (mg/100 g)          |
|---------|-------------------------|-------------------------|------------------------|------------------------|------------------------|
| Raw     | 25.61±0.34 <sup>a</sup> | 18.97±0.01 <sup>a</sup> | 7.00±0.06 <sup>c</sup> | 3.31±0.00 <sup>b</sup> | 0.41±0.02 <sup>a</sup> |
| Roasted | 30.34±0.02 <sup>b</sup> | 22.76±0.01 <sup>b</sup> | 6.40±0.15 <sup>b</sup> | 2.43±0.02 <sup>a</sup> | 0.41±0.01 <sup>a</sup> |
| Boiled  | 80.88±0.02 <sup>c</sup> | 60.68±0.02 <sup>c</sup> | 5.80±0.10 <sup>a</sup> | 4.23±0.02 <sup>c</sup> | 1.23±0.01 <sup>b</sup> |

Mean value with different superscript alphabets in each column are significantly different from each other by DMRT (P<0.05).

**Table 3.** Mean constituents of the vitamin nutrients observed in raw and processed (boiled and roasted) seeds of *A. pavonina*.

| Sample  | β-Carotene (iu)           | Vitamin E (iu)          |
|---------|---------------------------|-------------------------|
| Raw     | 1458.33±0.01 <sup>b</sup> | 22.50±0.02 <sup>c</sup> |
| Roasted | 416.67±1.20 <sup>a</sup>  | 9.24±0.02 <sup>a</sup>  |
| Boiled  | 416.67±0.88 <sup>a</sup>  | 12.69±0.01 <sup>b</sup> |

Mean value with different superscript alphabets in each column are significantly different from each other by DMRT (P<0.05).

**Table 4.** Mean constituents of the anti-nutrients observed in raw and processed (roasted and boiled) seeds of *A. pavonina*.

| Sample  | Tannin (%)             | Phytate (%)            | Oxalate (%)            | Cyanide (%)            | Trypsin inhibitor (%)  |
|---------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Raw     | 1.21±0.00 <sup>c</sup> | 5.16±0.02 <sup>c</sup> | 0.34±0.00 <sup>c</sup> | 1.17±0.00 <sup>c</sup> | 0.92±0.01 <sup>c</sup> |
| Roasted | 0.49±0.00 <sup>b</sup> | 3.50±0.01 <sup>b</sup> | 0.13±0.00 <sup>b</sup> | 0.95±0.00 <sup>b</sup> | 0.36±0.01 <sup>b</sup> |
| Boiled  | 0.15±0.00 <sup>a</sup> | 1.50±0.02 <sup>a</sup> | 0.11±0.00 <sup>a</sup> | 0.32±0.00 <sup>a</sup> | 0.90±0.01 <sup>a</sup> |

Mean value with different superscript alphabets in each column are significantly different from each other by DMRT (P<0.05).

nutrients in the seeds (Table 2). Processing significantly increased the percentage compositions of calcium, magnesium, iron and potassium.

Analysis of variance (ANOVA) showed significant difference (P<0.05) in the vitamin composition of the processed (roasted and boiled) seeds of *A. pavonina* when compared with the raw (control) seeds. Processing methods affected the composition of vitamin nutrients in the seeds. Processing significantly reduced the vitamins A and E constituents (Table 3).

There was significant difference (P<0.05) in the anti-nutrients composition of the processed (roasted and boiled) seeds when compared with the raw seeds. Processing methods affected the composition of anti-nutrients in the seeds. The anti-nutrients were generally reduced in the processed seeds and the boiling gave the most significant effect (Table 4).

## DISCUSSION

The results from the nutritional analysis showed that the values for the major nutrients tested are within the reported values for other legumes (Aremu et al., 2006).

Protein composition of processed *A. pavonina* seeds is comparable to that found in the seeds of soybean, *Canavalia ensiformis* and cowpea (El-Adaway and Taha, 2001), and much higher than that of bambara groundnut (Akaninwor and Ogechukwu, 2004). Carbohydrate level is favorably compared with the acceptable range mean values for legumes (20 to 60%) (Aykroyd and Dought, 1964), and higher as compared to that of *C. ensiformis*, soybean and *Mucuna utilis* (Balogun and Olatidoye, 2012). The carbohydrate content gave an indication that the seeds of *A. pavonina* studied here can be considered as a rich source of energy and is able to supply the daily energy requirements of the body in children and adults (Aranda et al., 2001; Balogun and Olatidoye, 2012). The seeds of *A. pavonina* contained higher crude fats than most other legumes. Legumes generally have low fat content in the range of 1 to 2% with the exception of *Cicer arietinum*, *Glycine max* and pea nut (Costa et al., 2006). The same appreciable result was recorded for crude fibre, moisture content and ash.

Furthermore, processing methods were observed to significantly (P<0.05) affect the nutrient composition when compared with the raw seeds. Boiled seeds had higher amount of protein than roasted seeds. In addition,

regarding the recommended daily allowance for proteins for children, which ranges from 23.0 to 36.0 g, and for adult (44 to 56 g), it can be considered that the boiled seeds of *A. pavonina* can supplement the recommended daily intake of this nutrient, particularly for children. Therefore, this appreciable proteins content in the processed seeds suggests their usefulness as alternative source of protein nutrients. The fat composition obtained from the processed seeds of *A. pavonina* studied showed that processing significantly ( $P < 0.05$ ) affected the fat composition of the seeds. Roasted seeds had the highest amount of fat than the boiled seeds.

The crude fibre content of the roasted seeds was significantly ( $P < 0.05$ ) higher than the boiled seeds and the overall fibre content of *A. pavonina* was higher when compared with those of other legumes, for example, *Dolichos tribalus*, *Vigna radiata* and *Vigna unguiculata* (Aremu et al., 2006). Processing methods therefore, affected the crude fibre composition, with the roasted seeds having more amount than the boiled seeds, and this implied that more of the crude fibres were probably leached into water during boiling (Aremu et al., 2006).

The moisture composition of the roasted seeds of *A. pavonina* was significantly ( $P < 0.05$ ) lower in comparison with boiled seeds. This was expected as seeds are subjected to higher temperatures during roasting. The result indicate that roasting may favor keeping quality and acceptability of *A. pavonina* seeds as texture, taste, appearance and stability of foods depends on the amount of water they contain (Isengard, 2001).

The ash composition of the processed seeds of *A. pavonina* was reflective of the high level of some mineral elements presented in Table 2. The roasted seeds had significantly ( $P < 0.05$ ) higher amount of ash than the boiled seeds. The low value of ash in the raw seeds may be as a result of the effects of anti-nutrients on the mineral contents of the food sample. The ash content reported here is higher as compared to the recommended values and suggested that these seeds are rich source of ash (Kala and Mohan, 2008).

Table 2 shows that processing significantly ( $P < 0.05$ ) increased some mineral contents of *A. pavonina* seeds with boiling having the most significant increased effect. This is probably because minerals are not destroyed by heat. The reduction in some cases may be as a result of leaching of minerals into the boiling water and through roasting process (Amarowicz et al., 2009). This study revealed that seeds of *A. pavonina* are rich in mineral elements including calcium, phosphorus, potassium, magnesium and iron. These minerals are necessary for cell formation, transmission of nerve impulse, fluid balance and bone formation (Ezeagu and Ologhobo, 1995).

In this study, vitamins A ( $\beta$  carotene) and E compositions of the seeds of *A. pavonina* were significantly ( $P < 0.05$ ) reduced by processing methods when compared with the raw seeds. This agrees with an

earlier report that processing of legumes by heating lead to reduction of vitamin content (Asogwa and Onweluzo, 2010). This could be explained by the fact that vitamins are lost during processing because of their high sensitivity to oxidation, and leaching into water soluble media during storage (Davy et al., 2010).

The result of the anti-nutrient values of the processed seeds of *A. pavonina* showed that processing methods significantly ( $P < 0.05$ ) reduced the anti-nutrient composition of the seeds when compared with the raw seeds (Table 4). It has been reported that some anti-nutrients are heat labile and therefore will be reduced to a great extent by the application of heat to the food (Ameta and Olegbobe, 1994), and this statement has been justified in this result as boiling most significantly reduced all the anti-nutrients to very low levels in seeds of *A. pavonina*. Roasted seeds showed higher increase in phytate content because of the increase in phosphorus concentration since phytate is the major store of phosphorus in mature seeds, while the boiled seeds showed reduced amount of phytic acid which is attributed to leaching in water.

## Conclusion

Processing methods adopted in this study have been proven to have significant effects on the nutritional and anti-nutritional compositions of the seeds of *A. pavonina*, a highly nutritious and neglected legume, in agreement with earlier reports that thermal processes of legumes enhance tenderization of the cotyledons, thereby increasing palatability and nutritional value by inactivating endogenous toxic factors. In addition, it was observed that boiling gave higher significant effect than roasting and proved as more efficient method of processing the seeds. Furthermore, this study revealed that the seeds, when properly processed, have high nutritional values that can be exploited and considered as an alternative source of nutrients to reduce malnutrition among economically weaker categories of people in the developing countries.

## Conflicts of Interests

The authors have not declared any conflict of interests.

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