Full Length Research Paper

Effect of boiling and roasting on the nutrient composition of kidney beans seed flour

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Accepted 11 February, 2015

This research work addresses the nutrient and anti-nutrient composition of raw and processed seed flours of the white variety of kidney bean (*Phaseolus vulgaris*) seeds. Although kidney bean is considered as one of the neglected tropical legumes, it could be used effectively to improve the nutritional well being of Nigerians, because of its high protein content. The kidney bean seeds were either boiled or roasted; raw seeds served as control. The seeds were milled into flour and analyzed for proximate, and some vitamins and minerals. Anti nutrients were also determined. Data was subjected to analysis of variance and means were separated by Duncan multiple range test. Processing significantly (p<0.05) reduced carbohydrate content from 60.09% in raw to 54.49% in boiled sample; protein was significantly (p<0.05) increased from 20.92% in raw to 25.24% in roasted samples. Iron (Fe) was significantly reduced (p<0.05) from 23.04 ppm in raw to 19.92 ppm in the roasted samples. Vitamins A and E were also significantly reduced (p<0.05) by processing. Processing significantly (p<0.05) reduced the anti-nutrient levels in the kidney bean. Roasting process reduced tannin by 52% while Phytohaemaglutinin was reduced by 45%. Kidney bean seeds flour are good sources of micro and macronutrients.

Key words: Processing, boiling, roasting, nutrient composition, anti- nutrients, under-utilized, kidney bean.

INTRODUCTION

Globally, food insecurity is worsening. In many developing countries like Nigeria, the situation is getting worse by factors like climate change, flood, and civil unrest (Boko haram saga) e.t.c. These unfortunate incidences have increased the occurrence of malnutrition in Nigeria (Asogwa and Onweluzo, 2010). Many families depend only on carbohydrate staples like cassava, yam and rice to feed their children. When protein foods are taken; they are not taken in such quantities that will improve the persistent occurrence of protein energy especially from the plant proteins. One way to achieve this is by promoting the use of plant biodiversity, hence dietary diversity. This can be done through the promotion and utilization of under-utilized food crops. Many malnutrition. This is not surprising as the cost of purchasing food items like meat, fish, milk, and eggs are out of the reach of these masses. There is therefore an urgent need to find alternative sources of proteins, underutilized crops, especially legumes, abound in Nigeria; they can be used to fill the gap created by high cost of staples, animal proteins, and commonly eaten plant protein sources like cowpea and soya beans.

Under-utilized food crops also have under exploited potential to contribute to food and nutrition security, health, and income generation (Asogwa and Onweluzo, 2010). Legumes generally contain relatively high amount of protein than other plant food stuff. Kidney bean (*Phaseolus vulgaris*), is one of the neglected tropical legumes that can be used to improve the nutritional well being of Nigerians, because of its high protein content (Akobundu et al., 1999). It is also a rich source of vitamin,
minerals and relatively high in crude fibre (NAS, 1999). Even though kidney bean has a lot to offer nutritionally, it is still an underutilized food crop in Nigeria, it has not gained wide spread industrial, nutritional and economic importance both at the household and national levels; because of its hard to cook nature and presence of anti-nutrients as well (Fasoyiro et al., 2009; Audu and Aremu, 2011). Antinutrients have been reported to affect the bioavailability of food (Aremu et al., 2010). Unless these antinutrients are destroyed by heat or other treatments, they can exert adverse physiological effects when ingested by man and animals (Liener, 1994).

Boiling and roasting are important household food processing methods. Boiling is the act of cooking food in water that is bubbling vigorously, while roasting is cooking food in an uncovered pan without water to produce a well-browned exterior and a moister cooked interior. These processing treatments are also effective in eliminating the antinutritional factors in foods (Nzewi and Egbonou, 2011). The effects of some processing methods on the nutritional values of some legumes have been reported (Nwosu, 2010; Olaofe et al., 2010). However, to the knowledge of the authors, no report has been given on the effect of processing methods on the nutritional values of the white variety of kidney bean seed flour. This work is aimed at determining the nutrients and anti-nutrients content of raw and processed (boiling, roasting) kidney bean seed flour with a view to providing information towards effective utilization of kidney beans in various food applications, which will be used for optimal nutrient retention, hence improved nutritional status of consumers.

MATERIALS AND METHODS

Collection and preparation of sample

The kidney bean seeds were purchased at Bode market, in Ibadan, Oyo state Nigeria. The seeds were cleaned and extraneous materials like dry leaves, stones, and dirt were removed and divided into three portions. The first part was ground raw and used as control; the second part was roasted and the third part was boiled.

Production of roasted seed flour

Traditional roasting method was applied (Audu and Aremu, 2011), with slight modification; here the beans were steeped in cold water for 75 minutes and then dehulled. The dehulled seeds were oven dried at 40°C for 40 min that is, until for constant weight was achieved; the dried seeds were then roasted in a frying pan at a temperature of 120°C using kerosene stove. The seeds were continuously stirred until a golden brown colour was obtained. The roasted seeds were allowed to cool and then ground to flour by a hammer mill model 303 SAP. The flour was able to pass through a sieve of aperture size <300 mm. The roasted seed flour was packed into labeled capped bottle and transferred to the laboratory for proximate, micronutrients and anti-nutrients determination.

Production of boiled seed flour

The seeds were boiled according to the method of Audu and Aremu (2011); with slight modifications. 100 g of whole beans was boiled in water at 100°C for 3 h at the ratio of 1:14 (w/v). The seeds were considered boiled when the endosperms were easily crushed by a gentle press between the thumb and index fingers. The boiled sample was allowed to cool, and then oven dried at 40°C for 7 h after drying, the boiled kidney beans were allowed to cool and then ground to flour by a hammer mill model 303 SAP. The flour was able to pass through a sieve of aperture size <300 mm. The boiled seed flour was packed into labeled capped bottle and transferred to the laboratory for proximate, micronutrients, and antinutrients determination.

Proximate determination of raw and processed seed flour

Method of AOAC (2000) was used to determine protein, ash, crude-fibre, fat and moisture in processed and raw samples. The protein content was determined by digestion using micro-Kjedahl method where total Nitrogen was determined; crude protein was calculated by the formula N x 6.25; fat content was determined by the continuous solvent extraction method using soxhlet apparatus; crude fibre was determined gravimetrically; total ash content was determined by furnace incineration; carbohydrate was determined by difference. Carbohydrate (%) = (100 - crude protein+ crude lipid+ crude fibre + ash).

Micronutrient analyses

For iron and zinc determination, samples were mineralized in a digester block according to AOAC (2000). The mineralized solution was analyzed for iron (Fe) and zinc (Zn) using a Perkin-Elmer model 300 atomic absorption spectrophotometer (Norwalk CT), equipped with a deuterium lamp for background correction.

Pro vitamin A (β-carotene) content was determined by the method adopted by IVACG (1992). UV absorption measurement of the samples was made at 328 nm after
Vitamin E (mg/day) consumed was described by Price et al. (1978). Tannin content was determined as earlier reported by Oshodi and Aletor (1993) but with slight modifications.

\[
\text{Vitamin E (µg/100g)} = \frac{\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dil. Factor}}{\text{Weight of sample}}
\]

Vitamin A was determined as described earlier by Amadi et al. (2012) with slight modification. 1 g of each sample was weighed into a conical flask with reflux condenser, 10 ml of absolute alcohol and 20 ml of 1 M alcoholic sulphuric acid was added. The condenser and conical flask was wrapped in aluminium foil and refluxed for 45 min, after cooling; 50 ml of distilled water was added to the mixture and transferred to separatory funnel with 50 ml water. The unsaponifiable matter was extracted with 30 ml diethyl ether. The combined ether extract was washed free from acid and was dried over anhydrous sodium tetra oxosulphate (VI). The residue obtained was immediately dissolved in 10 ml absolute alcohol. Aliquots of solutions of the sample and standards (0.3-3.0 mg Vitamin E) transferred into 20 ml volumetric flasks; 5 ml alcohol was added, followed by 1 ml HNO₃ concentrated Trioxo-nitrate (V) acid. The flasks were placed on a water bath at 90°C for 3 min from the time the alcohol begins to boil; it was cooled rapidly under running water and adjusted to volume with absolute alcohol. The absorbance was read at 470 nm on a metromhspectronic 21D spectrophotometer, against a blank containing 5 ml absolute alcohol and 1 ml concentrated HNO₃ treated in a similar manner.

\[
\text{Vitamin E} \quad (\mu g/100g) = \frac{\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dil. Factor}}{\text{Weight of sample}}
\]

Anti-nutrient analyses of raw and processed kidney bean seed flour

Tannin content was determined as described by Price et al. (1978). Saponin was determined by the method of Segal et al. (1966). Lectin was determined as earlier reported by Oshodi and Aletor (1993) but with slight modifications.

Two (2) g of sample was weighed into 250 ml beaker, 50 ml of solvent mixture of isobutyl alcohol and trichloroacetic acid were added and allowed to shake on a UDY shaker for 6 h to extract the haemaglutinin. The mixture was filtered through a double layer filter paper into a 250 ml conical flask and maintained in a water bath for 2 h at 80°C. The filtrate was allowed to cool and a set of standard solutions of haemaglutinin ranging from 0 to 10 ppm were prepared from haemaglutinin stock solution. The absorbances of the standard solution as well as that of the filtrate were read at 220 nm on a digital spectrophotometer 21D.

\[
\% \text{Phytohaemaglutinin} = \frac{\text{Absorbance of sample} \times \text{Average gradient of standards} \times \text{Dilution factor}}{10,000}
\]

RESULTS AND DISCUSSION

The Data in Table 1 shows that values for all nutrients range within reported values for other legumes like scarlet runner bean (Aremu et al., 2010) and bambara nut (Olaofe et al., 2010). The low moisture content of the flours indicates that it would store well and nutrients would be preserved. It has been reported that higher moisture content leads to food spoilage through microbial actions (Onyeike et al., 1995). Reduced moisture content ensures the inhibition of microbial growth, hence is an important factor in food preservation (Chew et al., 2011). Roasted kidney bean sample had lower moisture content in comparison with boiled seeds; this is expected as seeds are subjected to higher temperatures during roasting. The result indicates that roasting may favor keeping quality of white kidney bean seeds.

Carbohydrate has the highest composition by percentage in all the samples, with raw seed flour having the highest value (60.09%). This indicates that the kidney bean flour will be a good source of energy for consumers; especially young children. The fat content for all samples is lower than that reported for red kidney beans (Audu and Aremu, 2011), this variance may be due to varietal difference. Values of 2.88, 2.56, and 3.62% for boiled, raw and roasted samples respectively, revealed that kidney bean is not a good source of fat. Legumes which are known to be good sources of fat include groundnut
Table 2. Mean vitamin content of raw and processed seed flours of kidney bean (*Phaseolus vulgaris*).

<table>
<thead>
<tr>
<th>Vitamins</th>
<th>Boiled sample (µg/100g)</th>
<th>Roasted sample (µg/100g)</th>
<th>Raw sample (µg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>1037.12±1.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>964.42±1.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1230.15±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>83.70±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>80.12±0.42&lt;sup&gt;c&lt;/sup&gt;</td>
<td>90.50±1.10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations ± S.D. Means in the same row followed by the same superscript are not significantly different at p<0.05.

Table 3. Mean mineral content of raw and processed seed flours of kidney bean (*Phaseolus vulgaris*).

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Boiled sample (ppm)</th>
<th>Roasted sample (ppm)</th>
<th>Raw sample (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>21.07±1.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.92±1.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>23.04±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Zinc</td>
<td>17.94±0.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.72±1.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.32±1.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations ± S.D. Means in the same row followed by the same superscript are not significantly different at p<0.05.

and soybeans. The protein values of the flour from processed kidney bean seeds were significantly higher (p<0.05) than that of the raw, this is in agreement with earlier report that processing of wild jack bean (*canavalia ensiformis*) improved its protein content and protein availability (Dosss et al., 2011). The increase in the protein value of the processed kidney bean seeds may be due to break down of crude protein to amino acids during processing, Oboh (2006). The high values obtained for protein in this research (20.92% in raw seed to 25.24% in roasted seed) indicates that kidney bean is a good source of protein and compares favorably with values obtained for other legumes like cowpea (Obatolu et al., 2001) and pigeon pea (Fasoyirote et al., 2009). It has been earlier reported that when food is subjected to roasting, the activity of proteolytic enzymes is increased (Mbah et al., 2012). The higher protein value obtained for the roasted sample is due to the increased activity of proteolytic enzymes, which hydrolysed inherent proteins to their constituent amino acids and peptides.

The ash content of the samples ranged from 3.29% in the raw seed sample and 4.29% in the boiled seed sample, the result obtained is similar to the 4.4% reported for red kidney beans (Audu and Aremu, 2011). The low value of ash in the raw sample may be as a result of the effect of anti-nutrients on the mineral contents of the food sample, previous work had reported that anti-nutrients could interfere with the bioavailability of minerals (Alonso et al., 2001; Anigo et al., 2009); however, since anti-nutrients are heat labile, processing had reduced the levels of the anti-nutrient, thereby improving the bioavailability of the minerals as seen in the resultant increase in the ash values of flour from processed kidney bean seeds.

The fibre content of flour from raw and processed kidney bean seed fall within the acceptable range of 2.7 to 7.9% (Eke et al., 2008). The importance of fibre in human diet cannot be over emphasized. Fibre helps to maintain the health of gastro intestinal tract, and also prevent colon cancer (Audu and Aremu, 2011).

Table 2 above reveals that processing significantly (p<0.05) reduced the vitamin content of kidney bean flour, this agrees with an earlier report that processing of legumes by heating led to reduction of vitamin content (Asogwa and Onweluzo, 2010). Davey et al. (2000) had explained that vitamins are lost during heat processing because of their high sensitivity to oxidation, and leaching into water soluble media during storage. Boiling and roasting reduced Vitamin A value of the sample by 15.70 and 21.60%, respectively; while vitamin E was reduced by 7.52 and 11.47% by boiling and roasting respectively. The values obtained for vitamin E for all samples is much higher than the 15 mg/day recommended daily allowance of vitamin E for adults (FNB, 2000). Vitamin A is needed for good eye sight; vitamins A and E are anti oxidants which play a major role in fighting diseases like cancer, diabetes and slow down the natural aging process (Olanipekun et al., 2011).

Table 3 shows the mineral composition of raw and processed seed flours of kidney bean. Processing reduced the mineral content of the samples; with roasting having a higher reducing effect than boiling. Minerals are not destroyed by exposure to heat (Amarowicz et al., 2009). The reduction in this case may be as a result of
leaching of minerals into the boiling water, and the removal of the seed coat of the kidney bean before roasting. The removal of bran, or seed coat have been implicated in the reduction of minerals in grains (Damodaran, et al., 2008). The results obtained for iron and zinc in this work (23.04 and 18.32 ppm) were higher than values of 12.7 and 10.2 ppm obtained for iron and zinc, respectively in raw mangoave legume (Seena et al., 2006). Earlier report stated that the seed flour of red kidney bean had Iron and Zinc values of 11.5 and 2.7 ppm, respectively (Audu and Aremu, 2011); these values are lower than the values obtained in this study; the difference in the values may be varietal. Zinc has been shown to promote wound healing, and also play a role in taste, appetite and growth (Alayande et al., 2012). Iron is an essential mineral in human health, playing a role in immune function, cardiovascular health and cognitive development (Seena et al., 2006).

The result of the anti-nutrient value of the raw and processed seed flour of kidney bean seeds showed that processing significantly (p<0.05) reduced the anti-nutrient content of the 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 (Apata and Ologhobo, 1994). It was observed that roasting reduced the anti-nutrients to very low levels. The value of 0.2% of tannin in the raw kidney bean was lower than the 0.7 and 0.24% reported earlier for raw cowpea and raw pigeon pea respectively (Price et al., 1980); this suggests that the tannin content in the kidney bean will have no adverse effect on consumers. The Tannin and Saponin values obtained for the raw and processed kidney beans were within safe levels (Gurfinkel and Rao., 2002). However, the value of 33.18% obtained for phytohaemaglutinin in raw kidney bean was not within safe values (Gurfinkel and Rao., 2002) Kidney bean must be heat treated before consumption to prevent deleterious effects; reports have it that animals fed on raw kidney beans exhibited various physiological disorders like increase in relative weight of pancreas and liver, and also diarrhea (Marzo et al., 2002; Arija et al., 2006). As thermal processes, boiling and roasting of legumes could enhance tenderization of the cotyledons thereby increasing palatability and nutritional value by inactivating endogenous toxic factors (Nzewi and Egbunu, 2011).

Conclusions

The major findings in this research indicated that kidney bean seed flours (raw and processed) had low fat and moisture content, indicating that it would keep well when stored. The processed and raw kidney bean seed flour is good sources of micronutrients and macronutrients, and could be used in areas where accessibility and affordability for other legumes are inadequate, for vegetarians and non - vegetarians. The inclusion of kidney bean flour as a blend in recipe development can help to alleviate the problem of malnutrition prevalent in rural areas of Nigeria. Recommendation is therefore given for effective production and appropriate utilization of white variety of kidney bean seeds.

REFERENCES


Table 4. Mean anti-nutrient values of raw and processed seed flours of kidney bean

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tannin (%)</th>
<th>Saponin (%)</th>
<th>PHA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sample</td>
<td>0.21 ±0.00</td>
<td>0.05 ±0.00</td>
<td>33.18 ±0.01</td>
</tr>
<tr>
<td>Boiled sample</td>
<td>0.13 ±0.01</td>
<td>0.05 ±0.00</td>
<td>26.29 ±0.02</td>
</tr>
<tr>
<td>Roasted sample</td>
<td>0.10 ±0.02</td>
<td>0.03 ±0.00</td>
<td>18.36 ±0.01</td>
</tr>
</tbody>
</table>

Values are means of 3 determinations ± SEM. Means within the same column with different superscripts are significantly different at p<0.05

PHA = Phyto-haemaglutinin.


