Nigerian J. Anim. Sci. 2018, 20 (1): 134-144

Evaluation of differently processed kidney bean seeds on nutrient and anti-nutrient compositions: implications for monogastric animal feeding

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Target audience: *Monogastric animal farmers, researchers, students and feed industries*

Abstract

The study aimed at evaluating the effect of cooking duration and toasting on proximate composition, vitamins, minerals, amino acid and phytochemical contents of kidney bean seed. The seeds were obtained from Akwanga market in Akwanga L.G.A. of Nasarawa State, Nigeria, cleaned and extraneous materials like dry leaves, stones, and dirt were removed and cooked for 1, 2, 3 and 4 hours; another portion was toasted using aluminum pan where toasting was done until the seeds turn brown, producing sweet aroma as that ground nut cake. The cooked ones were labeled T2, T3, T4, and T5 for 1, 2, 3 and 4 hours of cooking duration, respectively while the raw and toasted were labeled as T1 and T6, respectively. Samples of each treatment were analyzed for nutrients and anti-nutrients compositions. The cooking durations showed significant ($P<0.05$) increase in nutrients and decrease in anti-nutrient compositions compared to the unprocessed seeds. Similarly, toasting showed deviations in all the nutrients and anti-nutrients analyzed. The low phytochemical values recorded in cooked and toasted seeds were within safe limits for both human and animals' consumption. It is therefore concluded that Kidney bean must be cooked at least for 3 hours or toasted before feeding to monogastric animals to prevent deleterious effects.

Keywords: *Cooking duration, toasting, nutrients, phytochemical compositions, kidney beans and monogastric animals.*

Description of Problem

The utilization and exploitation of a crop generally depends on the available knowledge on it. The dearth of information on Kidney beans in lieu with their optimum nutritional and functional properties has made this potentially beneficial legume under-utilized.

Under-utilized food crops also have under exploited potential to contribute to food and nutrition security, health, and income generation (8). Legumes refer to the seeds of Leguminosae including peas, beans and pulses. Legumes are considered as "poor man's meat" due to their high protein content and low cost compared to meat and meat products (10). Legumes generally contain relatively high amount of protein than other plant food stuff. Though legumes are important sources of dietary proteins for human and animals, their usefulness have been hindered by the presence of some anti–nutritional factors known as toxins (26; 6). Kidney bean (*Phaseolus vulgaris*), is an herbaceous annual plant of the family leguminosae. It is domesticated independently in ancient Mesoamerica and the Andes; although widely cultivated in hot climate throughout the world. It 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 (2). It is also a rich source of

vitamin minerals and relatively high in crude fibre (19). 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 antinutrients as well (13; 9).

Nutritional quality is affected by these factors that interact with the intestinal tract such as phytate, tannins and oxalates which reduce protein digestibility and amino acid absorption (20; 11). However, these substances need to be destroyed either by heat or other treatments otherwise concentration of toxins will exert adverse physiological effects when ingested by man and animals (16). Processing methods such as dehusking, soaking, germination, cooking and roasting inactivate the antinutrients and can be used to improve the nutritional quality of the beans (12; 28). The objective of the present work is to determine the effect of cooking duration and toasting on proximate composition, vitamins, minerals, amino acid and phytochemical contents of kidney beans seed (*Phaseolus vulgaris*).

Materials and Methods

Collection and preparation of samples

Cooking

The kidney bean seeds were purchased at Akwanga Market, in Akwanga, Nasarawa State Nigeria. The seeds were cleaned and extraneous materials like dry leaves, stones, and dirt were removed and divided into 5 portions. The first part was uncooked (raw), the second part was cooked for 1hour; the third part was cooked for two hours; the fourth part was cooked for 3 hours, and the fifth part was cooked for 4 hours, representing T1, T2, T3, T4 and T5.

Toasting

Another sample of the seeds was toasted using an open pan until it turns brown, producing sweet aroma similar to that produced when toasting groundnut representing T6.

The raw, cooked and toasted bean samples were oven dried to constant mass, milled separately to a particle size of about 0.2mm using mortar and pestle, packaged in a low density polyethylene bag (LDPE) and kept in a cool dry place pending analysis.

Proximate analysis

Proximate analysis of the kidney bean was carried out to at the Institute for Agricultural Research and Training, Ibadan, Oyo State, Nigeria to determine crude protein, ether extract, crude fibre, ash, moisture content, NFE and energy using the methods of (4). Replicate determinations were made whereby the average and standard deviations are reported.

Vitamins and minerals analysis

Samples were dry-ashed according to (4). Aliquots were analyzed for mineral components of potassium, sodium and iron using atomic absorption spectrophotometer (Buck, 210 Model) while phosphorus was determined calorimetrically (4).

Amino acid analysis

The amino acids were quantitatively measured by the procedure of (30) using automated amino acid analyzer (Technicon Sequential Multi-sample Analyzer, TSM). Sample was hydrolyzed for determination of all amino acids except tryptophan in

consistent boiling hydrochloric acid for 22 hrs under nitrogen flush.

Phytochemical analysis

Phytochemical examination of the oven dried and grinded samples were carried out using the standard methods (29, 31, 15).

Statistical analysis

Data were subjected to analysis of variance and means were compared with Duncan Multiple range test using SPSS (version 20, IBM SPSS Statistics, US).

Results and Discussion

Effect of cooking duration on proximate and metabolizable energy composition of Kidney bean seeds

The results of the effect of cooking duration on proximate composition of kidney bean (*Pheasolus*vulgaris) are presented in Table 1. The crude protein ranged from 8.83 to 19.02% with the control (0hr) recording the lowest and toasted kidney been seed recording the highest protein content. However, there was no significant difference in the crude protein contents of kidney bean cooked for both 2, 3hours and toasted respectively. These values are in conformity with values obtained in previous studies (9) but relatively lower than that those reported by (24). The increase in the protein value of the processed kidney bean seeds as affected by cooking duration may be due to increased bioavailability of nutrients associated with breakdown of food materials during processing (23). The high values obtained for protein in this research (18.34% to 18.49%) indicates that kidney bean is a good source of protein and compares favorably with values obtained for other legumes like cowpea (22).

The fat content (ether extract) for all samples is lower than that reported for red kidney beans (9), this variance may be due to varietal difference. Values of between 2.24, and 3.87%, revealed that kidney bean is not a good source of fat.

Crude fiber refers to the indigestible plant material. It lowers blood cholesterol level in humans, prevents cancer, and reduces the risk of developing diabetes, hypertension, and hypercholesterolemia. The fiber content recorded in the current study ranged between 1.86% and 2.84% with the control treatment recording the highest value while kidney beans cooked for 3hrs recorded the lowest value. These values obtained in this study are lower than the values recorded by (24; 9). Current results for different cooked and toasted kidney beans are in agreement with findings of (13) who recorded values of 1.98% to 7.20% fiber for different legumes.

Results for ash content demonstrated significantly highest values in 4hrs cooking (3.68%), 2hrs cooking (3.50%) and 1 hour cooking (3.37) but were found to be lowest in the control (0 hour) (1.31); these values are similar to those previously reported by (24; 32 and 9).

Moisture content estimates directly the water content and indirectly the dry matter content of the sample. The moisture contents of the five cooked kidney bean ranged from 6.78% to 10.71% kidney bean cooked for 3 hours recoding the lowest moisture content (6.78%) while the control (0hour) recorded the highest moisture content (10.71). Results obtained in the current study agrees with earlier findings (24 and 32) but significantly greater than the result reported by (9).

Nitrogen free extract (carbohydrate) has the highest composition by percentage in all the samples; with the control (0hour)

having the highest value (72.55%). This indicates that the kidney bean flour can be a good source of energy for poultry birds and humans.

The energy contents obtained in this study were between 2848.46 and 3319.77 kcal/kg, ME which were found to be higher than 313 to 328kcal/100g reported in literatures (18; 13). The metabolizable energy in this study showed that the bean has an energy concentration more favourable than cereals (1). The values for metabolizable energy compare favourable well with those reported for some legumes such as Bambara groundnut (1691.3 J/100 g), kersting's groundnut (1692.9 kJ/100 g) cranberry beans (1,651.7 kJ/100 g) (6).

Table 1: Effect of cooking duration on proximate and metabolizable energy composition of Kidney bean seeds

Nutrients %	T1 (0hr)	T2 (1hr)	T3 (2hrs)	T4 (3hrs)	T5 (4hrs)	SEM	LOS
Crude protein	8.83^{d}	15.4^{c}	18.34^{a}	18.49^{a}	17.03^{b}	1.59	**
Ether extract	3.78^{a}	2.24^{ab}	2.80^{a}	3.71^{a}	3.17^{a}	0.29	**
Crude fibre	2.84^{a}	2.49^{a}	2.28^{a}	1.86^{b}	2.65^{a}	0.15	**
Ash	1.31^{c}	3.37^{a}	3.50^{a}	2.82^{b}	3.68^{a}	0.38	**
Moisture	10.71	9.77	8.15	6.78	8.01	0.96	NS
NFE	72.55^{a}	66.70^{b}	66.19^{b}	66.36^{b}	65.47^{b}	1.15	**
Energy (ME, kcal/kg)	3193.02	2848.46	3176.53	3305.64	3187.30	2.18	**

SEM = Standard Error of Means, * - Significantly Difference (P< 0.05), NS – Not Significant (P>0.05), LOS- Level of significance, NFE – Nitrogen free extracts

Effect of cooking duration on vitamins and minerals composi-tions of Kidney bean seeds

Table 2 presents the vitamin and minerals composition of cooked kidney bean. The result reveals that cooking duration and toasting significantly ($p<0.05$) increased the vitamin content of kidney bean, this is in contradiction with an earlier report that processing of legumes by heating led to reduction of vitamin content (8).

Cooking increased the content of vitamin A (63.42 and 71.99 µg/100g) and vitamin B_3 (2.29 to 2.73(mg/100g) values of the seeds while vitamin E was reduced. All the minerals analyzed were significantly ($P<0.05$) improved due to cooking. This observation is in consonance with earlier assertion that pre-digestion or processing improves bioavailability of mineral to animals compared to raw or unprocessed seeds (3).

Table 2: Effect of cooking duration on vitamins of Kidney bean seeds

Nutrients	T1 (0hr)	T2 (1hr)	T3 (2hrs)	T4 (3hrs)	T5 (4hrs)	SEM	LOS
Vitamin A (µg/100g)	18.81^{c}	63.42^{b}	68.14^{a}	71.42^{a}	69.35^{ab}	176.49	**
Vitamin B_3 (mg/100g)	2.29	2.59	2.73	2.66	2.67	0.35	NS
Vitamin E (mg/100g)	0.38	0.35	0.26	0.36	0.34	0.14	NS
Sodium (%)	0.005	0.013	0.014	0.014	0.017	0.0016	NS
Potassium (%)	0.317^{b}	0.881^{a}	0.881^{a}	0.875^{a}	0..886^{a}	0.098	**
Calcium (%)	0.012^{c}	0.136^{a}	0.139^{a}	0.134^{a}	0.143^{b}	0.0067^{a}	**
Phosphorus (%)	0.273^{d}	0.365^{c}	0369^{b}	0.364^{c}	0.377^{a}	0.02	**
Magnesium (%)	0.095	0.281	0.287	0.283	0.291	0.04	NS

SEM = Standard Error of Means, * Significantly Difference (P< 0.05), NS – Not Significant (P>0.05), LOS- Level of significance.

Effect of cooking duration on amino acid profile of Kidney bean seeds

The result of amino acid profile of cooked kidney bean seed is presented in Table 3. The results revealed that amino acids increased significantly with increase in cooking time. Lysine was highest (1.54%) in cooked kidney bean for 4 hours and lowest (0.27%) in the control treatment. Methionine was lowest (0.22%) in the control treatment but highest (0.45%) in kidney bean cooked for 4 hours, while tryptophan was lowest (0.09%) in raw kidney bean and highest (0.23%) in kidney cooked for 4 hours. The result of this study is lower compared to 7.0% and 6.2% for lysine, 1.7% and 1.3% as earlier reported (9) for raw and cooked kidney bean.

Table 3: Effect of cooking duration on amino acid of Kidney bean seeds

Nutrients	T1 (0hr)	T2 (1hr)	T3 (2hrs)	T4 (3hrs)	T5 (4hrs)	SEM	LOS
Lysine	0.27	1.4	1.48	1.47	1.54	0.21	NS
Methionine	0.22	0.38	0.47	0.43	0.54	0.16	NS
Tryptophan	0.09	0.12	0.18	0.17	0.23	0.02	NS

SEM = Standard Error of Means, * Significantly Difference (P< 0.05), NS – Not Significant (P>0.05), LOS- Level of significance.

Effect of cooking duration on phytochemical composition of Kidney bean seeds

The result of phytochemical contents of kidney beans exposed to different cooking duration is presented in Table 4. The result showed that cooking duration significantly (P<0.05) reduced the anti-nutrient content of the seeds as earlier reported (5) that some anti-nutrients are heat-labile and therefore will be reduced to a great extent by the application of heat to the food. It was observed that cooking reduced the anti-nutrients to tolerable level. Tannin value (0.0012%) in the raw kidney bean and (0.0034%) in the cooked kidney bean was lower than the (0.7%) and (0.24%) as reported for raw cowpea and raw pigeon pea, respectively (27); this suggests that the tannin content in the kidney bean will have no adverse effect on monogastric animals. Saponin value obtained was higher (0.140%) in the raw kidney and lowest (0.107%) in kidney bean toasted kidney bean seed. Phytate value was also highest (0.018%) in the raw

kidney bean and lowest (0.015%) in the kidney bean cooked for 3 hours. Oxlate and flavonoids also followed similar trend as they were higher in the raw kidney and lowest in the cooked kidney bean. However, trypsin inhibitor did not follow the trend as it was lowest (1.95 ì/mg) in the raw kidney and highest (19.26 ì/mg) in kidney bean cooked for 1 hour. There was no significant difference (P>0.05) in saponin, phytate, oxalate and flavonoids values of the differently cooked kidney bean. The tannin, saponin, phytate, oxalate and flavanoids values obtained for the raw and processed kidney beans were within safe levels (14).

Kidney bean must be cooked 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 (17; 7). 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 (21).

Table 4: Effect of cooking duration on phytochemical composition of Kidney bean seeds

Nutrients %	T1 (0hr)	T2 (1hr)	T3 (2hrs)	T4 (3hrs)	T5 (4hrs)	SEM	LOS
Tannin	0.0012	0.0034	0.0034	0.0027	0.0028	0.00030	**
Saponin	0.1400	0.1260	0.1260	0.1170	0.1200	0.00040	NS
Phytate	0.0180	0.0168	0.0168	0.0158	0.0162	0.00040	NS
Oxalate	0.0163	0.0125	0.0125	0.0115	0.0118	0.00080	NS
Flavonoids	0.0007	0.0076	0.0076	0.0070	0.0068	0.00040	NS
Trypsin Inhibitor (µ/mg)	1.95^{c}	19.26^{a}	15.45^{a}	13.26^{a}	11.57^{ab}	1.89	**

SEM = Standard Error of Means, * Significantly Different (P< 0.05), NS – Not Significant (P>0.05), LOS- Level of significance.

Effect of toasting on proximate composition of Kidney bean seeds

The results of proximate composition of raw and toasted kidney beans are presented in Table 5. The results show that crude protein (19.02%), ether extract (3.87%), ash (2.69%) and energy (3319.77 kcal/100kg) were highest in the toasted kidney bean seed (T6) compared to the raw. However, crude fibre (2.84%), moisture (10.71%) and nitrogen-free extract (72.55%) were higher in the raw kidney bean seed. These values are lower than 20.92% and 25.24% as earlier obtained (27) and (7). The high values obtained for crude protein in toasted kidney bean in the present study indicates that kidney bean is a good source of protein and compares favorably with values obtained for other legumes like cowpea (24). The fat content (ether extract) for all samples are lower than that reported for red kidney beans (10). This variance may be due to varietal differences. Values of 3.78%, and 3.87% for raw and toasted kidney bean revealed that kidney bean is not a good source of fat.

Crude fiber refers to the indigestible plant material. It lowers blood cholesterol level in humans, prevents cancer, and reduces the risk of developing diabetes,

hypertension, and hypercholesterolemia. The fiber content recorded in the current study was 2.84% and 2.49% with the raw kidney beans recording the highest value while toasted kidney beans recorded the lowest value and are lower than the values earlier recorded by (27; 10). The values for ash content in this study were 1.31% and 2.69% for raw and toasted kidney bean seeds and are lower compared to previously reported values by (27, 35, 10).

Moisture content estimates directly the water content and indirectly the dry matter content of the sample. Results of moisture content obtained in this study agrees with the previous findings of (27, 35) but significantly higher than the earlier result reported by (10). Nitrogen-free extract has the highest value in all the samples, with the raw kidney bean seed having the highest value (72.55%). This indicates that the kidney bean flour can be a good source of energy for poultry birds and humans. The energy contents obtained in this study were 3193.02kcal/kg and 3319.77 kcal/kg for raw and toasted kidney bean seed, respectively. The energy values obtained were found to be higher than 313 to 328kcal/100g previously reported by (20) and (15). The metabolizable energy in this study showed that the sample has an energy concentration more favourable than cereals (1). The values for metabolizable energy compare favourably well with those reported for some legumes such as Bambara groundnut (1691.3 J/100 g), kersting's groundnut (1692.9 kJ/100 g) cranberry beans (1,651.7 kJ/100 g) (6).

Table 5: Effect of toasting on proximate composition of kidney bean seeds

Nutrients	T1(Raw)	T6 (Toasted)	SEM	LOS
Crude protein (%)	8.83	19.02	3.60	**
Ether extract (%)	3.78	3.87	0.43	NS
Crude fibre (%)	2.84	2.49	0.13	NS
Ash (%)	1.31	2.69	0.49	NS
Moisture (%)	10.71	6.10	1.63	**
NFE (%)	72.55	65.85	43.57	**
Energy (ME, kcal/kg)	3193.02	3319.77	44.91	**

*Significantly different (P< 0.05), NS – Not significant difference (P>0.05), LOS- Level of Significance, SEM-Standard error of means

Effect of toasting on vitamin and mineral compositions of Kidney bean seeds

Table 6 presents the vitamin and mineral compositions of raw and toasted kidney bean seed. The result reveals that toasting increased the vitamin A and B_2 contents of the kidney bean seed, this is in contradiction with an earlier report that processing of legumes by heating led to reduction of vitamins content (9). Vitamin A values of the toasted sample was 18.81g/100g and 71.99g/100g for raw. There was a reduction in vitamin E due to toasting; the values obtained for all the samples are much lower than the 15 mg/day recommended daily allowance for monogastric animals. 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 ageing process (26). Toasting increased the mineral availability of the samples but were not significantly (P>0.05) different; they are not destroyed by exposure to heat (3).

Table 6: Effect of toasting on vitamins and minerals compositions of Kidney bean seeds

Nutrients	T1(Raw)	T6 (Toasted)	SEM	LOS
Vitamin A (µg/100g)	18.81[c]	71.99[b]	18.860[a]	**
Vitamin B_2 (mg/100g)	2.29	2.68	0.140	NS
Vitamin E (mg/100g)	0.38	0.34	0.014	NS
Sodium (%)	0.005	0.017	0.004	NS
Potassium (%)	0.317	0.892	0.200	NS
Calcium (%)	0.012	0.142	0.050	NS
Phosphorus (%)	0.273	0.372	0.030	NS
Magnesium (%)	0.095	0.284	0.060	NS

*Significantly different (P< 0.05), NS – Not significant difference (P>0.05), LOS- Level of significance, SEM-Standard error of means.

Effect of toasting on phytoche-mical screening of Kidney bean seeds

The result of the effect of toasting on the phytochemical contents of kidney bean seeds is presented in Table 7. The result showed that toasting reduced the anti-nutrient contents of the seeds. This result tallies with the earlier reported (5) that some anti-nutrients are heat labile and therefore will be reduced to a great extent by the application of heat to the food. It was observed that toasting reduced the anti-nutrients to very large extent. Tannin value (0.0012%) in the raw was reduced to 0.0019% when toasted. These values are lower than 0.7% and 0.24% reported for raw cowpea and raw pigeon pea, respectively (29); this suggests that the tannin content in the toasted kidney bean seed will have no adverse effect on monogastric animals. Saponin value obtained was higher (0.140%) in the raw kidney and lowest (0.107%) in toasted kidney bean seed. Phytate value was also highest (0.018%) in the raw kidney bean compared to the toasted (0.013%). Oxalate and flavonoids also followed similar trend as they were reduced due to toasting. However, trypsin inhibitor did not follow the trend as there was significant increase (P<0.05) from raw to toasted seeds (1.95 and 9.795 µ/mg).

Table 7: Effect of toasting on phytochemical screening of Kidney bean seeds

Nutrients %	T1(Raw)	T6 (Toasted)	SEM	LOS
Tannin	0.0012	0.0019	0.0004	NS
Saponin	0.140	0.107	0.0400	NS
Phytate	0.018	0.0133	0.0090	NS
Oxalate	0.0163	0.0101	0.0400	NS
Flavonoids	0.0007	0.0057	0.0020	NS
Trypsin Inhibitor (µ/mg)	1.95[b]	9.795[a]	3.1000	**

*Significantly different (P< 0.05), NS – Not significant difference (P>0.05), LOS- Level of significance, SEM-Standard error of means.

Effect of toasting on amino acid profile of Kidney bean seeds

Table 8 shows the result of amino acid profile of raw and toasted kidney bean seeds. There was an increase in all the acid analyzed due to toasting. Methionine (0.50%), tryptophan (0.22%) and lysine (1.54%) were numerically higher in toasted kidney bean seeds as compared to the raw seeds values. The values obtained in the present study were lower compared to 7.0% and 6.2% for lysine, 1.7% and 1.3%

methionine as earlier reported (10). The study therefore concludes that kidney bean must undergo heat treatment before consumption to prevent deleterious effects; reports have it that broiler birds fed on raw kidney beans exhibited various physiological disorders such as increase in relative weight of pancreas and liver, and also diarrhea (19, 8). Thermal processes such as boiling and roasting of legumes could enhance tenderization of the cotyledons thereby increasing palatability and nutritional value by inactivating endogenous toxic factors (23).

Table 8: Effect of toasting on amino acid profile of Kidney bean seeds

Nutrients %	T1(Raw)	T6 (Toasted)	SEM	LOS
Lysine	0.27	1.54	0.49	NS
Methionine	0.22	0.50	0.17	NS
Tryptophan	0.09	0.22	0.07	NS

*Significantly different (P< 0.05), NS – Not significant difference (P>0.05), LOS- Level of significance, SEM-Standard error of means.

Conclusions and applications

1. Kidney bean seeds have relatively high nutrient constituents. It therefore means that they could serve as protein supplement in livestock feed.
2. The low fat content suggests that it has the potential of being used as feed ingredient for monogastric and pseudo-ruminant animals in place of most conventional protein sources.
3. The mineral contents of the seeds suggest that they are viable animal feed ingredients.
4. *In vivo* studies on the Kidney bean seeds as a protein source should be investigated.

Acknowledgement

We the authors greatly appreciate the supports of the members of staff of the Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, the Laboratory Technologists of the Biochemistry Lab of the Department as well as those of IA&RT, Moor Plantation, Ibadan, Oyo State, Nigeria, for making this study a possibility.

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