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# PERFORMANCE OF BROILER CHICKENS FED DIETS CONTAINING KIDNEY BEAN (*Phaseolus vulgaris* L.) SEEDS SUBJECTED TO VARIOUS PROCESSING METHODS

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## ABSTRACT

A study was conducted to determine how kidney beans may best be utilized in the diets of broiler chickens. The kidney beans were procured and subjected to various processing methods, namely, sun-drying (raw seeds), boiling, toasting, fermenting and sprouting. The seeds from each processing method were used to compound feeds for broiler chickens at both starter and finisher phases. Another feed without kidney beans was made, which served as a control diet; it contained only the conventional protein feedstuffs (groundnut cake and soyabeans). The diets were iso-caloric and iso-nitrogenous. Three hundred and sixty (360) day-old broiler chicks of the strain, Cobb, were weighed and randomly distributed to the dietary treatments with 60 birds per treatment and 15 per replicate. There were six dietary treatments replicated four times in a completely randomized design. Weighed quantities of feeds were supplied to each replicate group at the beginning of each week. Left-over feeds were weighed at the end of the week and deducted from the feed supplied to determine the feed intake for the week. Data taken included feed intake and body weight; from where other parameters such as weight gain, feed-to-gain ratio, protein efficiency ratio and feed cost per kilogramme gain, were computed. At the end of the starter phase, the birds were fed a common diet, which did not contain kidney beans, for 7 days to remove the effect of the starter phase and to prepare them for the finisher phase. The data collection at the starter phase was repeated during the finisher phase. The starter and finisher phases lasted four weeks each. The feed intake of the starter broiler chicks fed boiled kidney bean diet (1739.25g) was significantly ($P<0.01$) higher than 1605.00g and 1546.25g for those fed fermented and toasted kidney bean diets, respectively. The feed intake of the birds fed boiled and fermented kidney bean diets were significantly ($P<0.01$) higher than 1524.00g for those fed the control diet. The weight gains of the birds fed boiled, toasted and fermented kidney bean diets 876.45g, 834.20g and 869.70g, respectively, did not differ significantly but were significantly ($P<0.01$) higher than 703.20g for those fed the control diet. During the finisher phase, the feed intake of the birds fed boiled, toasted and fermented kidney bean diets (4394.80g, 4302.80g and 4303.80g, respectively), were significantly ($P<0.01$) higher than 4194.00g for those fed the control diet. The weight gains of the birds fed boiled and fermented kidney bean diets did not differ significantly from each other and from the value for those fed the control diet. Boiling, toasting and fermentation of the dietary kidney beans resulted to weight gains in broiler chickens that were superior to the control treatment at both starter and finisher phases. Therefore, boiling, toasting or fermentation is recommended for processing kidney beans for inclusion in the diets of broiler chickens.

**Key words:** kidney beans, processing methods, broiler chickens

## INTRODUCTION

At present, the conventional protein ingredients for poultry feed production such as soyabeans and groundnut cake have become scarce and expensive due to the high demand for them for human consumption. Consequently, animal nutritionists in Nigeria and other developing countries have resorted to exploring other potential, and hitherto, neglected feed resources in order for the poultry industry to have a wider range of alternatives to choose from. The availability of alternative sources of nutrients will encourage a shift to the sources for which there is less competition from humans as food. Efforts have been made to use other vegetable protein sources such as pigeon pea (Amaefule and Obioha, 2001, Iorgyer *et al*, 2009, Iorgyer, 2010); *Mucuna pruriens* seeds (Emenalom and Udedibie, 1998; Tuleun *et al*., 2011) and Jackbean (Esonu *et al*., 1998) in monogastric diets with encouraging results. There are, however, many other legumes whose seeds can be explored for their nutritional value for monogastric animals. One of such legumes is the kidney beans (*Phaseolus vulgaris* L.).

Kidney bean is a leguminous crop grown in different parts of the world. Several varieties of this crop are currently cultivated in fairly large quantities in Mangu and Bokkos areas on the Jos Plateau, Nigeria. The varieties cultivated have crude protein contents ranging from 17 to 28% (Olomu, 2011), and are worth investigating for use as a possible protein ingredient in poultry feed production.

However, like other grain legumes, its usefulness as a feed ingredient for monogastric animals may be limited due to the presence of some anti-nutritional factors (Kingsley, 1995). The presence of anti-nutritional substances in feedstuffs has been associated with growth depression and pancreatic hypertrophy in many monogastric animal species (Birk, 1988; Olomu, 2011).

It has been established that heat treatment and other processing methods exert beneficial effects on the seeds of grain legumes by destroying the anti-nutritional factors inherent in them (Balogun *et al*., 2001). Some of the anti-nutritional factors are, however, thermostable, requiring different processing methods applied individually or in combination. For instance, the effectiveness of heat treatment in detoxifying tannin, phytate and oxalate in kidney beans has been found to be low (Emiola *et al*., 2007). Other processing methods need to be explored in addition to heat treatment in order to reduce the anti-nutritional factors to tolerable levels in the diets of broiler chickens.

The objective of this study was to determine the effect of processing methods of dietary kidney bean seeds on the performance of broiler chickens.

## MATERIALS AND METHODS

The red variety of kidney beans, the most widely cultivated on the Jos Plateau, Nigeria, was procured and subjected to various processing methods with the aim of destroying the anti-nutritional factors. The methods of processing employed were as described below:

**Sun-drying (raw seeds)**

The raw seeds procured from the market were sun-dried for 72 hours to minimize variations in their moisture content and ensure that they were sufficiently dried for feed production (approximately 90% dry matter). All the seeds procured were subjected to this treatment prior to the application of the other processing methods.

**Boiling**
The boiling of the kidney bean seeds involved heating the water to boiling point (100$^{o}$C) before turning the seeds into the boiling water as described by Bawa, (2003). Care was taken to ensure that the water was sufficient from the onset to cover the seeds throughout the cooking time. The seeds were then cooked for 60 minutes. The cooking time was taken from the moment the seeds were turned into the boiling water. Thereafter, the cooked seeds were drained of the water and sun-dried to less than 10% moisture.

**Toasting**
The toasting of the kidney bean seeds involved sprinkling some water onto them to facilitate deeper penetration of heat into the seeds, after which they were turned into an empty pan set on fire. The seeds were stirred continuously to ensure uniform heating, and to avoid charring. The heating continued until the seeds became crispy. They were then evacuated from the pan and sun-dried to less than 10% moisture.

**Fermenting**
The kidney bean seeds were first of all boiled for 60 minutes as described under 'Boiling' above; thereafter, they were drained of the water, turned into a plastic jar and covered for 72 hours to ferment. The fermented seeds were washed using clean water to remove any fungal growth and/or anti-nutritional factors that may be adhering to the surface of the seeds, and then sun-dried to less than 10% moisture.

**Sprouting of the seeds (for 96 hr)**
The kidney bean seeds were turned into a plastic jar containing enough water to cover the beans. They were left to soak for 12 hours, after which they were drained of the water, partially spread on the floor and covered with empty bags to induce sprouting. They were washed with clean water every 12 hours to prevent fungal growth, and then covered again on the floor. This was repeated daily for 4 days (96 hr) when over 90% sprouting was observed. The seeds were then sun-dried to less than 10% moisture.

The kidney beans in each processing method were subjected to proximate analysis and the determination of anti-nutritional factors to facilitate their use to make feeds for broiler chickens. The feeds were made for both starter and finisher phases. The dietary inclusion levels of the kidney beans were uniform across the treatments; variations were only in the methods of processing the beans. Another dietary treatment without kidney beans was used as a control treatment; it contained only the conventional protein feedstuffs (groundnut cake and soyabeans). The diets were iso-caloric and iso-nitrogenous (Tables 1 and 2).

Three hundred and sixty (360) day-old broiler chicks of the strain Cobb were procured for the study. They were weighed and randomly distributed to the six dietary treatments (60 birds per treatment and 15 per replicate). Each treatment was replicated four times in a completely randomized design. The birds were thereafter, weighed weekly. Weighed quantities of feeds were supplied to each replicate group at the beginning of each week. Left-over feeds were weighed at the end of the week and deducted from the feed supplied to determine the feed intake for the week. Data taken included feed intake and body weight, from where other parameters such as body weight gain, feed to gain ratio, protein efficiency ratio and feed cost per

**Table 1: Experimental Broiler Starter Diets containing Differently Processed Kidney Beans**

| | | Processing Methods of Kidney Bean Seeds | | | | |
|---|---|---|---|---|---|---|
| **Ingredients, %** | **Control** | **Raw** | **Boiled** | **Toasted** | **Fermented** | **Sprouted** |
| Maize | 50.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 |
| Wheat offal | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Kidney bean seeds | 0.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Groundnut cake | 29.30 | 21.70 | 21.70 | 21.70 | 21.70 | 21.70 |
| Full-fat soyabeans | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Limestone | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| Palm oil | 1.00 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Vit-mineral premix* | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| L-Lysine | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| DL-Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |
| **Chemical Analysis** | | | | | | |
| Crude Protein, % | 23.09 | 23.09 | 23.08 | 23.07 | 23.10 | 23.10 |
| ME, Kcal/kg | 3006 | 3010 | 3011 | 3009 | 3012 | 3010 |
| Energy to protein ratio | 130.19 | 130.36 | 130.46 | 130.43 | 130.39 | 130.30 |
| Ether extract, % | 7.26 | 9.09 | 10.06 | 10.10 | 9.90 | 9.95 |
| Crude fibre, % | 3.69 | 4.50 | 4.20 | 4.30 | 3.75 | 4.15 |
| Calcium, % | 1.04 | 1.06 | 1.04 | 1.05 | 1.07 | 1.04 |
| Avail. Phosphorus, % | 0.52 | 0.53 | 0.51 | 0.52 | 0.53 | 0.51 |
| Ca:P ratio | 2.00 | 2.00 | 2.04 | 2.02 | 2.02 | 2.04 |
| L-Lysine, % | 1.08 | 1.15 | 1.18 | 1.16 | 1.19 | 1.14 |
| Met+Cys, % | 0.90 | 0.88 | 0.91 | 0.89 | 0.96 | 0.87 |
| **Cost, ₦/kg** | **75.05** | **76.45** | **90.65** | **87.45** | **95.75** | **89.55** |

*Biomix® Broiler Premix supplied the following per kilogramme of diet:

Vitamin A, 12000 i.u.; Vitamin $D_3$, 2400 i.u.; Vitamin E, 27.6mg; Vitamin $K_3$, 2.4mg; Vitamin $B_1$, 2.16mg; Vitamin $B_2$, 6.0mg; Vitamin $B_6$, 3.6mg; Vitamin $B_{12}$, 0.018mg; Niacin, 33mg; Pantothenic acid, 9.0mg; Biotin, 0.072mg; Folic acid, 0.9mg; Choline chloride, 360mg; Cobalt, 0.24mg; Copper, 3.60mg; Iodine, 1.20mg; Iron, 24.0mg; Manganese, 48.0mg; Selenium, 0.24mg; Zinc, 36.0mg; Anti-oxidant, 1.50mg.

**Table 2: Experimental Broiler Finisher Diets containing Differently Processed Kidney Bean Seeds**

| | | Processing Methods of Kidney Bean Seeds | | | | |
|---|---|---|---|---|---|---|
| **Ingredients, %** | **Control** | **Raw** | **Boiled** | **Toasted** | **Fermented** | **Sprouted** |
| Maize | 54.55 | 39.55 | 39.55 | 39.55 | 39.55 | 39.55 |
| Wheat offal | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Kidney bean seeds | 0.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Groundnut cake | 20.00 | 12.50 | 12.50 | 12.50 | 12.50 | 12.50 |
| Full-fat soyabeans | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Limestone | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| Palm oil | 0.00 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| Common salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Vit-mineral premix* | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| L-Lysine | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| DL-Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |
| **Chemical Analysis** | | | | | | |
| Crude Protein, % | 20.13 | 20.16 | 20.18 | 20.17 | 20.19 | 20.16 |
| ME, Kcal/kg | 3021 | 3022 | 3020 | 3019 | 3017 | 3019 |
| Energy to protein ratio | 150.07 | 149.90 | 149.65 | 149.68 | 149.43 | 149.75 |
| Ether extract, % | 6.07 | 8.78 | 8.79 | 9.10 | 9.13 | 8.89 |
| Crude fibre, % | 3.76 | 4.52 | 4.55 | 4.90 | 4.15 | 4.65 |
| Calcium, % | 1.23 | 1.22 | 1.23 | 1.25 | 1.27 | 1.24 |
| Avail. Phosphorus, % | 0.51 | 0.52 | 0.50 | 0.52 | 0.53 | 0.51 |
| Ca:P ratio | 2.41 | 2.35 | 2.46 | 2.40 | 2.40 | 2.43 |
| L-Lysine, % | 1.08 | 1.15 | 1.18 | 1.16 | 1.19 | 1.14 |
| Met+Cys, % | 0.97 | 1.03 | 1.04 | 1.02 | 1.06 | 1.04 |
| **Cost, ₦/kg** | **69.76** | **71.13** | **85.33** | **82.13** | **90.43** | **84.43** |

*Biomix® Broiler Premix supplied the following per kilogramme of diet:

Vitamin A, 12000 i.u.; Vitamin $D_3$, 2400 i.u.; Vitamin E, 27.6mg; Vitamin $K_3$, 2.4mg; Vitamin $B_1$, 2.16mg; Vitamin $B_2$, 6.0mg; Vitamin $B_6$, 3.6mg; Vitamin $B_{12}$, 0.018mg; Niacin, 33mg; Pantothenic acid, 9.0mg; Biotin, 0.072mg; Folic acid, 0.9mg; Choline chloride, 360mg; Cobalt, 0.24mg; Copper, 3.60mg; Iodine, 1.20mg; Iron, 24.0mg; Manganese, 48.0mg; Selenium, 0.24mg; Zinc, 36.0mg; Anti-oxidant, 1.50mg.

kilogramme gain, were computed. Feed to gain ration was obtained by dividing the feed intake by the weight gain. Protein intake was determined by multiplying the feed intake figure by the protein content of the feed. Protein efficiency ratio was obtained by dividing the weight gain of the birds by their protein intake value. The starter and finisher phases of the experiment lasted four weeks each. At the end of the starter phase, the birds were placed on a common diet, which did not contain kidney beans, for 7 days to remove the effect of the starter phase. Thereafter, they were mixed together, weighed and randomly allocated to the dietary treatments for the finisher phase of the study. The weight of the birds taken at this point served as the initial weight for the finisher phase. Both feed and water were provided *ad libitum*. Data collection procedures were same as in the starter phase. Other routine poultry management procedures were carried out. Mortalities were recorded as they occurred.

The data on all the parameters were subjected to analysis of variance using the SAS (1995) procedure, and treatment means separated using the Duncan's Multiple Range Test as outlined by Obi (1990).

## RESULTS DISCUSSION

### Broiler Starter Phase (0 – 4 weeks of age)

The response of starter broiler chicks to various processing methods of dietary kidney bean seeds was as presented in Table 3. The chicks fed the diet containing boiled kidney beans had significantly ($P<0.01$) higher feed intake (1739.25g) than 1215.25g, 1546.25g, 1605.00g, 1265.25g and 1524.00g for the birds fed raw, toasted, fermented, sprouted and control diets, respectively. The birds fed fermented kidney bean diet also had a significantly ($P<0.01$) higher feed intake than those fed the control diet. The feed intake of the chicks fed toasted kidney bean diet was similar to the value for those fed the control diet, which was significantly ($P<0.01$) higher than the value for those fed sprouted kidney bean diet. The chicks fed the raw kidney bean diet had the least feed intake. The body weight gains of chicks fed boiled, fermented and toasted kidney bean diets (876.45g, 869.70g and 834.20g, respectively) did not differ significantly ($P>0.05$) from one another, but were significantly ($P<0.01$) higher than 703.20g for those fed the control diet. The birds with the highest protein efficiency ratio (PER) were those fed fermented kidney bean diet (2.42). Their PER was significantly ($P<0.05$) higher than 2.14, 2.19 and 2.41, for those fed the control, boiled and toasted kidney bean diets, respectively. These three did not differ significantly ($P<0.05$) in their PER values, but had significantly ($P<0.05$) higher PER than 1.77 and 1.88 for those fed sprouted and raw kidney bean diets, respectively. The birds fed sprouted kidney bean diet had a significantly ($P<0.01$) higher feed cost per kilogramme gain (₦202.50/kg) than those in all other treatments. The birds fed raw kidney bean diet did not differ significantly ($P>0.05$) in their feed cost per kilogramme gain from those fed the boiled kidney bean diet (₦179.05/kg and ₦178.90/kg, respectively), but had significantly ($P<0.01$) higher values than those fed fermented, toasted and control diets (₦172.00/kg, ₦162.00/kg and ₦152.33/kg), in that order of decreasing magnitude.

**Table 3: Response of Starter Broiler Chicks (0 – 4 weeks of age) to Processing Methods of Dietary Kidney Beans**

| | | Kidney Bean Processing Method | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter/bird** | **Control** | **Raw** | **Boiled** | **Toasted** | **Fermented** | **Sprouted** | **SEM** |
| Initial body weight (g) | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 |
| Daily feed intake (g) | 54.43$^{c}$ | 43.40$^{e}$ | 62.12$^{a}$ | 55.22$^{c}$ | 57.32$^{b}$ | 45.19$^{d}$ | 1.36** |
| Cumulative feed intake (g) | 1524.00$^{c}$ | 1215.25$^{e}$ | 1739.25$^{a}$ | 1546.25$^{c}$ | 1605.00$^{b}$ | 1265.25$^{d}$ | 13.70** |
| Final body weight (g) | 753.25$^{c}$ | 525.25$^{e}$ | 826.50$^{a}$ | 784.25$^{b}$ | 819.75$^{a}$ | 506.00$^{d}$ | 9.24** |
| Daily weight gain (g) | 25.11$^{b}$ | 16.97$^{c}$ | 31.30$^{a}$ | 29.79$^{a}$ | 31.06$^{a}$ | 19.86$^{c}$ | 1.21** |
| Cumulative weight gain (g) | 703.20$^{b}$ | 475.25$^{c}$ | 876.45$^{a}$ | 834.20$^{a}$ | 869.70$^{a}$ | 555.95$^{c}$ | 54.20** |
| Feed-to-gain ratio | 2.05$^{b}$ | 2.31$^{d}$ | 1.99$^{b}$ | 1.81$^{a}$ | 1.80$^{a}$ | 2.28$^{c}$ | 0.12* |
| Protein intake (g) | 351.89$^{c}$ | 280.36$^{e}$ | 401.25$^{a}$ | 356.72$^{c}$ | 370.27$^{b}$ | 316.89$^{d}$ | 3.64** |
| Protein efficiency ratio | 2.14$^{b}$ | 1.88$^{c}$ | 2.19$^{b}$ | 2.41$^{b}$ | 2.42$^{a}$ | 1.77$^{c}$ | 0.12* |
| Feed cost/kg gain (₦/kg) | 152.33$^{e}$ | 179.05$^{b}$ | 178.90$^{b}$ | 162.00$^{d}$ | 172.00$^{c}$ | 202.50$^{a}$ | 2.34** |

$^{abcde}$ Means within the same row bearing different superscripts are significantly different
SEM = Standard error of mean
* = P<0.05
** = P<0.01

**Table 4: Response of Finisher Broiler Chickens (5 – 9 weeks of age) to Processing Methods of Dietary Kidney Beans**

| | | Kidney Bean Processing Method | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter/bird** | **Control** | **Raw** | **Boiled** | **Toasted** | **Fermented** | **Sprouted** | **SEM** |
| Initial body weight (g) | 936.50 | 935.50 | 936.00 | 936.50 | 936.30 | 936.40 | - |
| Daily feed intake (g) | 149.79$^{c}$ | 154.25$^{b}$ | 156.96$^{a}$ | 153.67$^{b}$ | 153.71$^{b}$ | 146.81$^{d}$ | 3.21* |
| Cumulative feed intake (g) | 4194.00$^{c}$ | 4319.00$^{b}$ | 4394.80$^{a}$ | 4302.80$^{b}$ | 4303.80$^{b}$ | 4110.80$^{d}$ | 32.90* |
| Final body weight (g) | 2611.50$^{a}$ | 2275.50$^{c}$ | 2638.50$^{a}$ | 2520.00$^{b}$ | 2621.30$^{a}$ | 2300.65$^{c}$ | 18.47** |
| Daily weight gain (g) | 59.82$^{a}$ | 47.95$^{c}$ | 60.79$^{a}$ | 56.55$^{b}$ | 60.18$^{a}$ | 48.72$^{c}$ | 1.52** |
| Cumulative weight gain (g) | 1675.00$^{a}$ | 1342.50$^{c}$ | 1702.00$^{a}$ | 1583.50$^{b}$ | 1685.00$^{a}$ | 1364.25$^{c}$ | 18.48** |
| Feed-to-gain ratio | 2.52$^{b}$ | 3.22$^{a}$ | 2.59$^{b}$ | 2.72$^{b}$ | 2.56$^{b}$ | 3.02$^{a}$ | 0.13** |
| Protein Intake (g) | 844.25$^{c}$ | 870.71$^{b}$ | 885.98$^{a}$ | 867.43$^{b}$ | 867.64$^{b}$ | 828.73$^{d}$ | 6.63* |
| Protein efficiency ratio | 1.99$^{a}$ | 1.54$^{c}$ | 1.92$^{a}$ | 1.83$^{b}$ | 1.94$^{ab}$ | 1.65$^{c}$ | 0.07** |
| Feed cost/kg gain (₦/kg) | 174.77$^{d}$ | 225.21$^{b}$ | 217.76$^{c}$ | 221.54$^{b}$ | 223.31$^{b}$ | 251.69$^{a}$ | 2.23** |

$^{abcde}$ Means within the same row bearing different superscripts are significantly different
SEM = Standard error of mean
NS = Not significant
* = P<0.05
** = P<0.01

**Broiler Finisher Phase (5 – 9 weeks of age)**

The response of finisher broiler chickens to the methods of processing dietary kidney beans studied was as presented in Table 4. The feed intake of the chickens fed boiled kidney bean diet (4394.80g) was significantly (P<0.01) higher than 4319.00g, 4302.80g, 4303.80g, 4110.80g and 4194.00g for the birds fed diets containing raw, toasted, fermented and sprouted kidney beans, and the control diet, respectively. The feed intake of the birds fed raw, toasted and fermented kidney bean diets did not differ significantly (P>0.05) from one another, but were significantly (P<0.05) higher than for those fed the control and sprouted kidney bean diets. The birds fed boiled and fermented kidney bean diets did not differ significantly (P>0.05) in their weight gains from those fed the control diet (1702.00g, 1685.00g and 1675.00g, respectively), but had significantly (P<0.01) higher values than 1583.50g for those fed toasted kidney bean diet. There were no significant differences (P>0.05) between the weight gains and feed-to-gain ratios of the chickens fed sprouted kidney bean diet (1364.25g and 3.02, respectively) and those fed raw kidney bean diet (1342.50g and 3.22, respectively). The feed-to-gain ratios of the birds fed boiled, toasted and fermented kidney bean diets (2.59, 2.72 and 2.56, respectively) did not differ significantly (P>0.05) from 2.52 for those fed the control diet. The PER of the birds fed boiled and fermented kidney bean diets (1.92 and 1.94, respectively) did not differ significantly (P>0.05), but were higher (P<0.01) than 1.54 and 1.65 for those fed raw and sprouted kidney bean diets, respectively. The PER of the birds fed toasted kidney bean diet (1.83) did not differ (P>0.05) from 1.94 for those fed fermented kidney bean diet. The birds fed raw and sprouted kidney bean diets had the least PER. The feed cost per kilogramme gain of birds fed raw, toasted and fermented kidney bean diet (₦225.21/kg, ₦221.54/kg and ₦223.31/kg, respectively) did not differ significantly (P>0.05), but were significantly (P<0.01) higher than ₦217.76/kg for birds fed boiled kidney bean diet. The birds fed sprouted kidney bean diet had the highest feed cost per kilogramme gain (₦251.69/kg), and those fed the control diet had the least (₦174.77/kg).

## DISCUSSION

**Broiler Starter Phase (0 – 4 weeks of age)**

The significantly higher feed intake of the chicks fed boiled and fermented kidney bean diets indicate that boiling and fermentation of dietary kidney beans probably rendered their diets more palatable than other processing methods studied. The palatability of the feed in these treatments appeared to be higher than even that of the control diet. The low feed intake of the chicks fed the raw kidney bean diet could be due to the presence of anti-nutritional factors, which lowered the palatability of the feed. Saponins have been reported to reduce the palatability of livestock feeds due to their bitter taste (Malinow *et al*. (1987). The higher feed intake of birds fed the boiled, toasted and fermented kidney bean diets were accompanied by better utilization for growth as these birds had significantly (P<0.01) better feed-to-gain ratios than the chicks on all other treatments. This signifies a higher efficiency of feed utilization under these kidney bean processing methods as less feed was consumed for each kilogramme gain in body weight when compared to the birds fed even the control diet. This shows that heat treatment satisfactorily destroyed the anti-nutritional factors to bring about an efficient utilization of the dietary kidney beans by the broiler chicks, since all three processing methods involved the application of heat. This agrees with the findings of Emiola *et al*., (2007) who reported a higher feed intake and weight gain of chickens fed diets containing heat treated kidney beans than those fed dehulled kidney beans. The significantly higher protein efficiency ratios of chicks fed boiled, toasted and

fermented kidney bean diets shows that the protein content of those diets were more efficiently utilized by the chicks when compared to the values those fed raw and sprouted kidney bean diets. This accounts for their significantly higher body weights and weight gains than those fed the other diets. Sprouting appeared to be an inadequate processing method in this study because the feed intake, body weight gain and protein efficiency ratio of birds under this treatment were significantly lower, and feed cost per kilogram weight gain higher than those under boiling, toasting and fermentation.

**Broiler Finisher Phase (5 – 9 weeks of age)**

The feed intake of the chickens fed boiled kidney bean diet was significantly ($P<0.01$) higher than those of all other treatments. This corroborates an earlier postulation (Balogun, 2001) that heat treatment of dietary legume seeds significantly improved the palatability of the feed for broiler chickens. Boiling had a more positive effect on the utilization of dietary kidney beans than toasting by significantly improving feed intake and body weight gain of the birds at both starter and finisher phases. This is likely to be due to the deeper penetration of heat into the kidney bean seeds by the boiling water, whereas during toasting, the heating is usually more superficial. This agrees with the observation by Abeke (1997) that toasted beans may not be uniformly cooked as heat penetration into the seeds is not as effective as is the case with boiling. This high feed intake translated into significantly ($P<0.01$) higher mean body weights and weight gains. The feed intake values of the birds fed raw, toasted and fermented kidney bean diets did not differ significantly ($P>0.05$) from one another, but were significantly ($P<0.05$) higher than for those fed the control and sprouted kidney bean diets. The raw kidney beans did not significantly suppress the feed intake of the birds during the finisher phase of the study. This improved feed intake of the birds fed the raw kidney bean diet indicates that if broiler chickens are fed the conventional feed during the starter phase, the inclusion of up to 20% raw kidney beans in their finisher diet might be safe. There was no significant difference ($P>0.05$) between the weight gains and feed-to-gain ratios of the chickens fed sprouted kidney bean diet and those fed raw kidney bean diet. Oke *et al*., (1995) had observed that germination was the most effective method of processing legume seeds to remove oligosaccharides such as raffinose and stachyose in cowpea, that are not usually digested by intestinal enzymes but accumulate in the large intestine where they undergo fermentation to produce gases. Iyayi and Egharevba (1998) also observed a substantial increase in protein content of germinated seeds over the raw and heat-treated seeds. In view of these findings, one would have expected a higher feed utilization and weight gains of the birds under this treatment, but this was not the case. The efficient protein utilization by birds fed boiled, fermented and toasted kidney bean diets further accounts for their significantly higher weight gains. The feed cost per kilogramme gains of birds fed raw, toasted and fermented kidney bean diets did not differ significantly ($P>0.05$), but were significantly ($P<0.01$) higher than for those fed boiled kidney bean diet. The birds fed sprouted kidney bean diet had the highest feed cost per kilogramme gain, and those fed the control diet had the least. These variations may be due to differences in the processing costs of the kidney beans, and variations in the efficiencies of feed utilization across dietary treatments.

## CONCLUSION

Boiling, toasting and fermenting of the dietary kidney beans resulted to weight gains that were superior to the control treatment at both starter and finisher phases. These results confirmed the superiority of these processing methods of dietary kidney beans for broiler diets over sprouting.

Boiling, toasting or fermenting is recommended for processing kidney beans for inclusion in the diets of broiler chickens for their effectiveness in imparting high weight gains to broiler chickens.

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