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Full Length Research

Growth performance and economics of broiler chickens production fed full fat soy bean as affected by different processing

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ABSTRACT: An experiment was conducted to evaluate the performance and economics of broiler chickens production fed diets containing differently processed full fat soy bean. Five diets were formulated in which differently processed full fat soy bean containing sprouted, salt treated, cooked and roasted with raw soy bean as control. Two hundred and fifty (250) Anak 2000 broiler chicks were randomly allotted to five dietary treatments replicated five times in a randomized completely block design. Results showed that daily feed intake, daily weight gain, feed conversion ratio and feed efficiency ratio were significantly ($p<0.05$) affected by the different processing methods at starter, finisher and overall phases by the different processing methods. The feed cost (₦/kg gain) was lower in cooked soy bean (₦66.08) and highest in salt treated soy bean (₦ 83.56). It can be concluded that cooked soy bean was more efficient in enhancing growth performance of broiler chickens with concomitant reduction in feed cost.

Keywords: Broiler chickens, cost implication, processing, soy bean.

INTRODUCTION

Soy bean (*Glycine max* (L.) Merrill) is a principal vegetable protein source in animal feed industry in Nigeria. It is high in protein with unique biological value, its fat content contributes to the energy required for protein synthesis. Full fat soy bean contains between 38 to 40% crude protein (CP), 18% fat and 5% crude fibre (Smith, 2001). Soy bean can be used as a source of protein in poultry and swine diets. Soy bean proteins have a high biological value and high fat content and unsaturated fatty acids (Leeson and Summers 2005). The protein of soy bean can be comparable to that of animal protein sources such as meat and milk (Fabiyi and Hamidu, 2011). Metabolisable energy of 2800 to 3200k/cal/kg was reported in soy bean (Leeson and Summers 2005). The use of full fat soy bean in poultry industry would eliminate the cost of oil extraction in monogastric diets (Lesson et al., 1987).

Soy bean is also a good dietary source of amino acids, calcium, potassium, it is also a good source of iron and contributes thiamine, riboflavin and niacin to the diet (Iwe, 2003). Soy bean is limiting in sulphur containing amino acids such as methionine and cystein but contain sufficient lysine to overcome the lysine deficiency of cereal (Potter and Hotchkiss, 1995). Raw full fat soy bean cannot be used in poultry nutrition, because it contains various anti-nutritional factors such as trypsin inhibitor, lectins, saponins and goitrogenic factors that interfere with nutrient digestibility causing reduction of feed intake, growth rate and efficiency of feed utilization in broiler chickens (Ari et al., 2013; Maidala, 2015). Full fat soy bean contains anti nutritional factors that reduce the digestibility, bioavailability of nutrients and utilization of amino acids in monogastric and immature ruminants (Anderson Heffernan, et al., 1992; Maidala et al., 2011). Increasing the nutritional quality of soy bean and other legumes can be accomplished by several processing methods such as toasting, cooking, extruding, salt treatment, fermentation, germination pressure cooking, cooking, soaking, urea treatment (Akande and Fabiyi, 2010, Maidala et al., 2013).

The goal for the processing of seed legumes for poultry nutrition is to increase the nutritional value of feed and to maximize the bird performance. It is against this background that the research work attempted to evaluate processing methods of soy bean seeds on growth performance and cost implication of differently processed soy bean.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in Azare, Bauchi State, Nigeria with a latitude and longitude of 11°40′27″N and 10°11′28″E respectively. The climate of the study area is controlled by the inter tropical convergent zone (ITCZ) which is marked by the rainy and dry season. The major climate elements that influence the climate of the study area and affecting the farming system are temperature and precipitation (rainfall). The annual temperature ranged between 22 to 33^{0}C from April to May (Bashir et al.,2001) while the mean annual rainfall ranged between 615.6 to 985 mm with peak between July to August. The study area is in the Sudan savanna, the vegetation is greatly determined by the nature of the soil. The soil in the study area is aerosol with sandy and loamy sand texture and a high percolation rate.

Sources and processing of feed ingredients

The maize and soy bean were purchased in Azare Central Market. Fresh bones used as bone meal and wheat bran were purchased in Azare Central Market. The premix, lysine and methionine were purchased in Animal Care Kano, Kano State, Nigeria.

Methods of processing of feed ingredients

Dry heat treatment (roasting)

The cleaned raw soy bean seeds were poured into a bed of alluvial sand in half drum and heating the sand to about 100^{o}C. Sufficient quantities of the ingredients to cover two third of the area of sand was placed on the sand. Stirring of the ingredients was done constantly until they were roasted for the duration of thirty minutes (Cheva-Israkul and Tangtaweewipat, 1995). Grinding of the roasted beans produced full-fat soy bean meal.

Cooking

The raw soy bean seeds were sorted to ensure homogeneity of product and were cooked by bringing water in a half drum to boiling point and pouring the ingredients in the boiling water for thirty minutes (Fanimo, 1996; Kaankuka et al., 1996) to produce the cooked full-fat soy bean, they were then sun dried for 3 to 4 days and ground to produce the corresponding full fat soy bean meals.

Salt treatment

Salt solution is prepared by adding 3% salt of total weight of sample, dissolved in water and soaked the soy bean for twenty four hours (Ayanwale, 2006), then sun dried for 3 to 4 days and stored in bags. Salt treated full fat soy bean meals was produced by grinding the salt treated beans.

Sprouting

Sprouts of soy bean were done by soaking the seeds in water for 24 hours. The seeds were removed and germinated by spreading the seeds on jute bags and covered them with the same material and apply water on jute bags twice daily for three to four days (Echendu et al., 2009) until the seeds begin to sprout. Sprouted seeds of soy bean, were sun-dried and ground to produce the meals.

Experimental birds and their management

Anak 2000 broiler chicks were obtained from Zartech Farm Jos, Nigeria. The birds were housed in partitioned pens of 2.5 x 2.5 square metres covered with wood shavings as a litter material. The birds were brooded for one week at temperature of 32 to 35^{o}C using kerosene stove and electricity as a heat source. On arrival of the birds, they were removed from crates and allowed access to water containing antistress (Biovit®) and antibiotics to aid their adjustment. During the first week they were fed essential feed® broiler starter having 23% CP. All experimental birds were given feed and water *ad libitum* while routine management and vaccination were uniformly carried out.

Data collection

A weighed quantity of feed was fed daily and the left over weighed the next day. Daily feed intake was determined by difference between the left over and the quantity fed the previous day. Birds were individually weighted at the start of the experiment and weekly thereafter. Weekly gain was obtained by difference between the weight of two consecutive weeks and daily gain calculated by dividing the weekly gain by 7 (number of days in the week). Feed conversion ratio (FCR) which is the amount of feed consumed per unit gain was calculated.

$$\mathrm{FCR} = \frac{\text{Feed consumed}}{\text{Weight}}$$

Table 1. Ingredients and nutrient composition (%) of the differently processed soy bean diets fed to broiler starter at the starter phase (1 to 5 weeks).

Ingredients	Diets				
	1	2	3	4	5
	Raw	Sprouted	Salt	Roasted	Cooked
Maize	45.06	45.06	45.06	45.06	45.06
Soy bean (Full-fat)	36.04	36.04	36.04	36.04	36.04
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fishmeal	5.00	5.00	5.00	5.00	5.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Sodium chloride	0.25	0.25	0.25	0.25	0.25
lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Crude protein	23.00	23.00	23.00	23.00	23.00
Metabolisable energy(kcal/kg)	2800.00	2800.00	2800.00	2800.00	2800.00
Crude fibre	6.08	6.08	6.08	6.08	6.08
Ether extract	6.08	6.08	6.08	6.08	6.08
Calcium	1.42	1.42	1.42	1.42	1.42
Available phosphorus	0.95	0.95	0.95	0.95	0.95

Each kilogram contains; vit. A, 10,000,000 IU, vit. D_3 2,000,000 IU, Vit. E 23,000mg, Vit. K_3 2.000mg, Vit, B_1 1,800mg, Panthothenic Acid 7,500mg, Vit. B_6 3,000mg, Vit. B_{12} 15mg, Folic acid 750mg, Biotin 11260mg, Choline Chloride 300,000mg, Cobalt 200mg, Copper 3,000mg, Iodine 1,000mg, iron 20,000mg, Manganese 40,000mg, Selenium 200mg, Zinc 30,000mg, Antioxidant 1,250mg.

Feed efficiency was also calculated using the formula:

$$\mathrm{FE} = \frac{\text{Weight gain}}{\text{Feed consumed}}$$

The cost of the diets (N/kg) was calculated based on the prevailing market price (N/kg) of the ingredient used in the formulations at the time of experiment.

Design of the experiment

Two hundred and fifty Anak 2000 broiler chicks aged seven days were randomly allotted to five treatments. There were fifty chicks per treatment which was replicated five times (ten chicks per replicate) in a randomized completely block design (RCBD).

Experimental diets

The differently processed soy bean used in this experiment was milled and mixed with other ingredients to formulate five experimental diets containing raw, roasted, cooked, salt treated and sprouted soy bean designated as 1, 2, 3, 4, and 5, respectively. The diets were isocaloric and isonitrogenous. The diets were formulated to meet the 23% and 21% crude protein requirements of broiler chickens for the starter and finisher phases respectively. The ingredients and nutritional composition of the diets are presented in Tables 1 and 2, for broiler starter and finisher respectively.

Data analysis

Data generated were analyzed using Analysis of variance techniques using the Minitab software and means were separated using Duncan's multiple range test.

RESULTS

The performance characteristics of broiler chicks fed differently processed soy bean in the starter phase are shown in Table 3. The initial weight of the broiler chicks varied between 98.07 to 98.71 g and the difference between the values were similar. The final body weight varied between 618.80 g in raw soy bean to 1007.72 g in cooked soy bean and the values were affected by the different processing methods. The highest daily feed intake (67.23 g) ($p<0.05$) was obtained in broiler birds fed

Table 2. Ingredients and nutrient composition (%) of broiler finisher (21% CP) diets containing differently processed soy bean.

Ingredients	Diets				
	1	2	3	4	5
	Raw	Sprouted	Salt	Roasted	Cooked
Maize	45.06	45.06	45.06	45.06	45.06
Soy bean (Full-fat)	31.04	31.04	31.04	31.04	31.04
Wheat offal	15.00	15.00	15.00	15.00	15.00
Fishmeal	5.00	5.00	5.00	5.00	5.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Sodium chloride	0.25	0.25	0.25	0.25	0.25
lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Crude protein	21.00	21.00	21.00	21.00	21.00
Metabolisable energy(kcal/kg)	300.00	300.00	300.00	300.00	300.00
Crude fibre	4.34	4.34	4.34	4.34	4.34
Ether extract	8.53	8.53	8.53	8.53	8.53
Calcium	1.32	1.32	1.32	1.32	1.32
Available phosphorus	0.90	0.90	0.90	0.90	0.90

*Each kilogram contains Vit A 3600, 000iu. Vit. D_3 600.000 IU. Vit E 4.000.000mg. Vit B_1-B_6 640, 1600, 600, 4.00mg. Panthothenic acid 2000mg, Biotin 300mg. Manganese 16000mg. Manganese 16000mg. Selenium 80mg. Vit. K_3 600mg. Cobalt 80mg. Copper 1200mg. Zinc 12,000mg. Folic acid 200mg. Choline chloride 700000mg. Antioxidant 500mg.

Table 3. Performance of broiler chickens fed diets containing differently processed Soy bean at the starter phase (1-5 weeks of age).

Parameters	Diets					SEM
	1	2	3	4	5	
	Raw	Sprout	Salt	Cooked	Roasted	
Initial weight (g/b)	98.45	98.71	98.07	99.08	98.25	0.20^{NS}
Final weight (g/b)	618.80^{b}	792.12^{a}	761.60^{a}	1007.72^{a}	969.08^{a}	368.92*
Daily feed intake (g)	49.51^{b}	59.50^{a}	59.37^{a}	67.23^{a}	59.19^{a}	10.01*
Daily weight gain (g)	21.79^{b}	23.71^{b}	21.94^{b}	33.44^{a}	33.89^{a}	11.04*
Feed conversion ratio	2.27^{a}	2.50^{a}	2.98^{a}	1.66^{b}	1.76^{b}	0.84*
Feed efficiency	0.44^{b}	0.40^{b}	0.37^{b}	0.63^{a}	0.57^{a}	0.12*
Survivability (%)	94	100	98	98	98	-

SEM: Standard error of means, ^{abc}Means bearing different superscripts within the same row are statistically different (P<0.05).

diet 4 containing cooked soy bean which was similar to the values on diets 2, 3 and 5 containing sprouted, salted and roasted products, respectively. However, the lowest value of 49.51 g/bird/day was found in broiler chicks fed raw soy bean based-diet (diet 1). The highest daily weight gain (33.89 g) was observed on diet 5 (roasted soy bean) which did not differ from the value of 33.44 g in birds fed cooked (diet 4) while the lowest value of 21.79 g was obtained on diet 1 (raw soy bean) which was similar to the weight gain on diet 2 and 3. The feed conversion ratio and feed efficiency followed the same trend with best values on diets 4 and 5 (roasted soy bean and cooked soy bean) and were significantly ($p<0.05$) better than the values of birds on diets 1, 2 and 3. Most of the chicks survived during the starter phase with a survivability percentage of between 94 and 100% observed on diets 1 and 2, respectively.

The growth performances of broiler chickens at the finisher phase (5 to 8 weeks) as affected by different processing methods are presented in Table 4. The initial weight varied between 618.80 to 969.08 g and the values

Table 4. Performance of broiler chickens fed diets containing differently processed soy bean (5-8 weeks of age).

Parameters	Diets					SEM
	1	2	3	4	5	
	Raw	Sprout	Salt	Cooked	Roasted	
Initial weight (g/bird)	618.80 [b]	792.12[a]	761.60 [a]	1007.72 [a]	969.08 [a]	368.92*
Final weight (g/bird)	1440[c]	1909[b]	1510[c]	2013[a]	2350 [a]	258*
Daily feed intake (g)	92.54[b]	107.98[a]	108.96[a]	120.10[a]	107.16[a]	19.10*
Daily weight gain (g)	22.41[b]	32.94[a]	32.46[a]	35.34[a]	31.33[a]	4.32*
Feedconversion ratio	4.20[b]	3.35[a]	3.63[a]	3.04[a]	3.48[a]	0.21*
Feed efficiency	0.24[b]	0.31[a]	0.30[a]	0.29[a]	0.32[a]	0.08
Survivability %	94	100	100	100	100	-

SEM: Standard error of means, [abc]Means bearing superscripts within the same raw are statistically different (P<0.05).

Table 5. Pooled performance of broiler chickens fed diets containing differently processed soy bean (1-8 weeks of age).

Parameters	Diets					SEM
	1	2	3	4	5	
	Raw	Sprout	Salt	Cooked	Roasted	
Initial weight (g/bird)	98.45	98.71	98.07	99.08	98.25	0.20[NS]
Final weight (g/bird)	1440[c]	1909[b]	1510[c]	2013[b]	2350 [a]	258*
Daily feed intake (g)	71.03 [b]	83.74[a]	84.17[a]	87.62[a]	83.18[a]	7.53*
Daily weight gain (g)	22.10[c]	28.29[b]	27.20[b]	35.99[a]	34.61[a]	3.34*
Feed conversion ratio	3.24[b]	2.86[b]	3.18[b]	2.57[a]	2.41[a]	0.54*
Feed efficiency	0.34[b]	0.33[b]	0.33[b]	0.46[a]	0.45[a]	0.08*
Survivability (%)	88	96	98	98	98	-

SEM: Standard error of means, [abc]Means bearing different superscripts within the same row are statistically different (P<0.05).

were similar. The final weight ranged between 1440.00 g in raw soy bean to 2350 g in roasted soy bean and the values were affected (p<0.05) by the different processing methods. The daily feed intake ranged from 92.54 to 120.10 g and the difference between the values were significant (p<0.05). Daily weight gain ranged from 22.41 to 35.34 g and the difference between the values were significant (p<0.05) with inferior means in raw soy bean and superior means with differently processed soy bean (p<0.05). Feed conversion ratio ranged from 3.04 to 4.20 and the difference between the values were significant (p<0.05). The percentage survivability of broilers fed different processed soy bean ranged from 94 to 100%.

The overall performance of broiler chickens fed diets containing differently processed soy bean is presented in Table 5. The initial weight varied from 98.25 to 99.08 g on diets 5 and 4 respectively and was similar. The higher (p<0.05) final weight gave values of 2350 g was observed on diet 5 which was closely followed by diet 4 and 2 while the lowest values were obtained on diet 1 and 3 (1440 vs. 1510 g). The daily feed intake ranged from 71.03 to 87.62g and the difference between the values were significant (p<0.05). Daily weight gain ranged from 22.10 to 35.99 g and the difference between the values were significant (p<0.05). The overall feed conversion ratio ranged from 2.41 to 3.24 and the difference between the values is significant (p<0.05). The feed efficiency ratio ranged from 0.33 to 0.46 and the difference between the values is significant. The survivability of birds on the overall ranged from 88 to 98%

The economics of production of broilers fed differently processed soy bean are presented in Table 6. Total feed intake ranged from 3.98 to 4.91kg. The feed cost (₦/kg) ranged from ₦ 77.16 to ₦ 86.86.The total feed cost (₦) was highest in roasted soy bean (₦ 404.77). The total weight gain was highest in cooked soy bean (1.96) kg/bird and feed cost (₦/kg) gain was lower in cooked soy bean (₦ 206.75) and higher in salt-treated soy bean (₦ 262.24)

DISCUSSION

The reduced final weight (618.80 g) and the poorest feed intake was observed on raw soy bean (49.51 g) and could be attributed to antinutritional factor present in raw soy bean (Liener, 1994; Anderson Hafermann et al., 1992) which depressed feed intake and caused inhibition of intestinal digestion and absorption. The high feed intake (p<0.05) in cooked soy bean (67.23 g) can be attributed to effective processing of cooked soy bean (Iheukwumere et

Table 6. Economics of production of broilers fed differently processed soy bean.

Parameters	Diets				
	1	2	3	4	5
	Raw	Sprout	Salt	Cooked	Roasted
Initial weight (g/bird)	618.80[b]	792.12 [a]	761.60 [a]	1007.72 [a]	969.08 [a]
Final weight (g/bird)	1440.00[c]	1909.00[b]	1510.00[c]	2013.00[b]	2350.00 [a]
Cost per kg feed (₦ /kg)*	77.16	84.63	84.63	82.53	86.86
Total feed cost (₦)	307.09	396.91	398.60	405.22	404.77
Total weight gain(kg/bird)	1.24	1.58	1.52	1.96	1.94
Cost per kg gain (₦)	247.65	251.21	262.24	206.75	208.64

*Calculated based on the prevailing price of ingredients at the time of study.

al., 2008; Abeke et al., 2011; Ari et al., 2013). The low daily weight gain (21.79 g) of raw soy bean is a reflection of poor feed intake and utilization in raw soy bean. High daily weight gain in cooked soy bean (33.44 g) and roasted soy bean (33.89 g) is an indication of effective processing. The low feed conversion ratio in cooked soy bean (1.66) is an indication of effective processing and the values are better than 2.41 reported by Ayigun and Alphonsus (2014) on cooked and roasted soy bean. Poor feed conversion ratio in raw soy bean (2.27) and salt treated soy bean (2.50) is an indication of poor performance (Iheukwumere et al., 2008). The feed efficiency ratio is a reflection of feed intake and weight gain which is higher in cooked soy bean (0.63) and roasted soy bean (0.57) and lower in salt treated soy bean (0.37), sprouted soy bean (0.40) and raw soy bean (0.44). Chick's survivability is better in sprouted soy bean (100%) and worse in raw soy bean (94%). The antinutritional factors present in raw soy bean can cause mortality of broiler chicks.

The reduced final weight (1440.00 g) and low feed intake in raw soy bean (92.54 g) could be attributed to the presence of antinutritional factors in raw soy bean which was reported to depress feed intake (Liener, 1994; Anderson Hafermann et al., 1992). The high feed intake in differently processed soy bean ($p<0.05$) can be attributed to various degree of success in elimination of antinutritional factor in differently processed soy bean with cooked soy bean having the highest feed intake (120.10 g) ($p<0.05$) which confirm the earlier report of Ari et al. (2013) on thermally treated soy bean. Poor daily weight gain (22.41 g) reported in raw soy bean can be attributed to poor digestion and utilization of raw soy bean by broilers (Liener, 1994). The differently processed soy bean have a better utilization than the raw soy bean ($p<0.05$). Cooked soy bean had the better daily weight gain (35.34 g). Iheukwumere et al. (2008) had earlier reported better utilization of cooked soy bean in broilers over the other processing methods ($p<0.05$). Feed conversion ratio followed the same trend with highest in raw soy bean (4.20) which indicated poor utilization of feed ($p<0.05$). Feed efficiency were not affected by the different processing methods ($p>0.05$) even though raw soy bean has lower value (0.24) than the processed soy bean. The survivability of the birds revealed that antinutritional factors toxicity can be detrimental and results in death of broiler birds. Birds on raw soy bean recorded a 6% mortality compared to (0%) in the differently processed soy bean.

The overall performance of broilers fed differently processed soy bean showed that final body weight and daily feed intake were significantly ($p<0.05$) affected with lower values in raw soy bean (71.03 g vs. 1440.00 g)) and better values in cooked soy bean (87.62 g vs. 1909.00 g). This can be attributed to toxic metabolites in raw soy bean accompanied by other complications in the gastrointestinal tract such as absorption and erosion of the microvillus in small intestine (Liener, 1994; Anderson Hafermann et al., 1992). The daily weight gain followed the same trend being lower in raw soy bean (22.10 g) and higher ($p<0.05$) in cooked soy bean (35.99 g). The feed conversion ratio is significantly affected ($p<0.05$) being higher in raw soy bean (3.24) which indicated poor utilization of raw soy bean and lower in cooked soy bean (2.57) which indicated better utilization ($p<0.05$) and this reaffirmed the earlier report of Ari et al. (2013) on thermally processed soy bean.

The overall performance in feed efficiency was significantly affected ($p<0.05$). Birds on raw soy bean, sprouted soy bean and salt treated soy bean seeds had poor feed efficiency while birds on cooked soy bean had a better feed efficiency (0.46) and this indicated poor utilization (Iheukwumere et al., 2008). The survivability of birds is lower in raw soy bean (88%). Antinutritional factor in raw soy bean can cause the death of birds when fed for a prolonged period (1 to 8 weeks). Higher survivability indicated better chances of reaching market age in broiler birds.

The reduced unit feed cost (₦ 77.16) in raw soy bean is attributed to lack of additional cost of processing in raw soy bean as opposed to the high feed cost of the salt-treated soy bean (₦ 84.63) and the high labour in germinated soy bean (₦ 84.63). Ayanwale (2006) have reported additional cost in salt-treated and other alkaline treated soy bean. The depressed total feed cost of raw soy bean (₦ 307.09) can be attributed to low total feed intake (3.98 kg). The high total feed cost in cooked soy bean can be attributed

to high feed intake in cooked soy bean (4.91 kg). Weight gain is directly proportional to feed intake as such it was higher in cooked soy bean (1.96) and lower in raw soy bean (1.24). The feed cost (₦ /kg) per kg gain was higher in salt treated soy bean (₦262.24) and lowest in cooked soy bean (₦ 206.75).

Conclusion and recommendation

Considering the results of this study, different processing methods exert effects on the growth performance of broiler chickens, however, cooking of soy bean appears to be more effective than other processing methods with concomitant reduction in cost of production.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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