Nigerian J. Anim. Sci. 2013, vol. 15:71-82

Performance traits, nutrient utilization and cost implication of feeding different thermally treated soyabeans to broiler chickens

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Target audience: Feed millers, Poultry farmers, Extension workers and Researchers

Abstract

The effects of different thermally processed soyabeans on performance traits, nutrient utilization and cost implication of feeding different thermally treated soyabeans to broiler chickens were compared in this study using 240 day-old Anak broilers that were randomly divided into four (4) experimental groups of three replicates each. Dietary treatments were: T_1-Extrusion (control), T_2-Cooking, T_3 -Toasting and T_4-Roasting groups and were fed isocaloric and isonitrogenous diets. Variations were observed among treatments in the performance evaluation traits especially in feed intake, weight gain, feed conversion ratio (FCR) and performance indices. Dry matter and crude fibre values showed significant ($P<0.05$) differences at the starter phase only while no significant ($P>0.05$) difference was observed in the digestibility of other nutrients at both the starter and the finisher phases. Total income was highest in the toasting group while roasting gave the least income. Gross profit of N16,079.50, N20,865.30, N22,660.40 and N12,715.20 were respectively recorded for extrusion, cooking, toasting and roasting while the benefit/cost ratio were, 0.06, 0.62, 0.66 and 0.70 representing toasting, cooking, roasting and extrusion respectively. It was observed that cooking gave averagely better performance traits, nutrient utilization and economic return than in other treatment groups.

Keywords: Broilers, Cost implication, Nutrient utilization, Performance traits, Thermal processing

Description of Problem

In spite of the global interest in the search and evaluation of alternative feedstuffs that have the greatest potential as substitutes for maize, soybean meal and animal proteins in animal nutrition, the feed resource utilisation by monogastric animals are still negligible owing to constraints imposed by nutritional, technical and socio-economic factors (1) these include availability, in economic quantities, price competitiveness against the main feedstuff and nutritive values. Therefore, research into efficient utilisation of the traditional oilseeds remains key to the success of the poultry industry in developing countries.

Several thermal and hydro-thermal processing techniques of soyabean that are aimed at improving the nutritive values and removing ANFs have been documented (2, 3, and 4). These include: dry heating (5, 2), toasting (6), cooking (7), extrusion (8, 2), autoclaving (9) and infrared (10, 11, 12). In spite of the fact that thermal processing of soyabean is acknowledged to be very successful in enhancing the nutritional value of soyabeans and in reducing ANFs, prolonged dry heating and autoclaving results in amino acid destruction of the lysine content of the soybeans determined on acid hydrolysate after heat (13) as decreases in enzymic hydrolysate treatments were observed and lysine was considered to be inactivated and destroyed. These processes were affected by many and varied reports on the influence of temperature, temperature-time combinations on the ANFs, nutrient profile and utilization of soyabean and cost implications among other constraints.

Lack of standardisation of cooking time and temperature regimes and high technology required for either autoclaving, extrusion, micronization and other thermal based processing methods as well as the energy demand for these processes and their effects on the nutrient content and utilisation of the full fat soyabeans posed serious challenges to average feed processors and small scale poultry farmers. The aim of this experiment was to evaluate the performance traits, nutrient utilization and bio-economic implication of feeding different thermally treated soya beans to broiler chickens

Materials and Methods

Experimental site

This study was conducted at the Livestock Complex of College of Agriculture, Doma Road, Lafia which is located between latitude 8^0 and 9^0 North and longitude 80^0 and 90^0 East. The minimum temperature is 21.9 ^{0}C and maximum temperature of 37.6 ^{0}C between January to June and the average annual rainfall is 823 mm. The test ingredients were processed at both the Livestock Complex and the Nutrition Laboratory of the college while the final feed was compounded at the feed mill Unit of the complex.

Soyabean collection, Processing and Diet Preparation

Soyabeans seeds *(Glycine max)* were procured from a local market in Lafia metropolis of Nasarawa State, Nigeria. The collected seeds were cleaned by winnowing and hand picking of stones and debris. The raw soyabeans were subjected to three thermal and hydrothermal processing methods viz: cooking, toasting and roasting (dry heating)). Each of these processing methods served as experimental treatment groups to be compared with control (soyabean cake processed through extrusion treatment and obtained from Grand Cereals in Jos). The different thermal and hydothermal processes are described as follows:

Soyabeans cake (extrusion processing)

The soyabeans cake procured from Grand Cereals in Jos, Plateau State served as the control. This soyabeans cake was derived from oil extraction from the whole soyabeans. This procedure as described by (2) involved the initial conditioning of the soyabeans before forcing the product through a die. A high accompanying temperature was created by the friction (dry extrusion) or partly by steam injection (wet extrusion).

Cooking

The raw soyabeans (seeds) were sorted to ensure homogeneity of product. The soyabeans (seeds) were cleaned and poured into tower aluminium pot containing 50 litres of water per each batch of 50 kg of soyabeans. The soyabeans (seeds) were allowed to cook at 100 ^{0}C for 30 minutes according to the methods described by (7) and adopted by (4).

Toasting

The cleaned raw soyabeans seeds were poured into a hot metal dry pan (common driers). The soyabeans were toasted at an approximate temperature of 100 ^{0}C for 30 minutes. This is a modification of methods of [14]. The dried soyabeans seeds were spread to cool before grinding.

Roasting (dry heating)

In order to reduce the over thickness of the soyabeans seeds and to allow for even spread of heat in the dry heating process, a modification of the method of (14) was adopted. The experimental soyabeans samples were cleaned and pounded using pestle and mortar in order to increase the surface area of the seeds. One thousand (1000) grams of the seeds were weighed into a tray and roasted (dry heating) in batches using hot plate (Gallenkamp) Muffle Furnace size 2 at a set temperature of 100 ^{0}C for 30 minutes. The dry fried seeds were allowed to cool before packaging and grinding.

Diet preparation

The experimental fixed and variable ingredients were grinded using single grinding with Vent mill and a screen size of 3 mm before mixing. The compounded experimental feeds were packed in polythene bags, sealed, labelled and stored until required.

Experimental design and data collection

A total of two hundred and forty (240) day-old Anak broilers were randomly divided into four (4) experimental groups of three replicates each. Dietary treatments were, T1, T2, T3 and T4 representing *soyabean cake* (control), *cooking, toasting and roasting* groups at both starter and finisher phases. Randomized Complete Block (RCB) design was used having the test ingredients incorporated as the main sources of variation.

The starter diets were fed for five (5) weeks (1- 35 d) and the finisher diets were fed for four (4) weeks (36- 63 d). All experimental birds were given feed and water *ad libitum* while routine management and vaccinations were uniformly carried out. Records of average feed intake, average body weight and weight gain, mortality and digestibility records [15] and cost were taken while Performance traits like FCR, survival percentage and performance indices and digestibility percentages were computed as thus:

$$FCR = \frac{\text{Average feed intake per week}}{\text{average weight gain per week}}$$

Performance Index=.

$$\frac{\text{Survival percentage X weight gain/bird/week}}{\text{FCR}} \text{X } 100$$

Where Survival percentage = 100 – mortality percentage

Nutrient digestibility =

$$\frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{Nutrient\ intake}\ x100$$

Cost / benefit were computed as the ratio of the Total Cost (TC) of production to the Total Revenue (TR) generated.

Chemical analysis

Chemical composition of each of the thermally treated soyabeans samples, experimental diets and faecal collections were determined following standard methods (16).

***Statistic**:*

Data collected were subjected to one-way Analysis of Variance (ANOVA), means were separated where there were significant differences using Duncan's Multiple Range Test (17) using SPSS 16.0.

Results and Discussions

The chemical composition of the thermally treated soya beans and experimental broiler starter and finisher feeds are presented in Tables 1 and 2. The nutrient composition of these feeds is consistent with (18), the recommended feeding standards for broilers. The dry matter (DM) values ranged from 92.69% to 92.73% and 92.62 to 93.43% in the starter and finisher diets respectively, while the crude protein percentage ranged from 20.53 to 23.47% in the starter diets. The finisher diets had the crude protein ranged from 20.21 to 22.99%. The least crude fibre value in the starter diets was 4.75% (extrusion) and 5.19% (cooked) in the finisher diets. Ether extract (EE) percentage values were highest in cooked soyabean starter diets (13.40%) and (14.47%) in toasted soyabeans finisher diets. Total ash percentage range in the starter diets was from 12.55% to 15.99%

while in finisher diets; the range was from 9.31% to 9.96%. NFE values ranged from 34.08 to 40.71% in the starter diets and from 41.62 to 44.22% in the finisher diets. The highest calcium and phosphorous values in the starter diets were 2.92 and 1.43% respectively while 2.24 and 1.68% were the highest calcium and phosphorous values in the finisher diets. The metabolisable energy values of the starter diets ranged from 3388.13 to 3466.78 Kcal/Kg ME while the metabolisable energy value range of the finisher diets was from 3584.03 to 3721.6 Kcal/Kg ME.

In spite of the variations in the nutrient composition of the thermally processed soyabean diets, all the diets at both starter and finisher phases were within recommended range for the broilers in the tropics as reported by (19).

Table 1: Effect of Thermal processing on the Chemical composition of Soyabean

	Chemical composition (%)							
Thermal methods of Processing	Dry matter	Crude protein	Crude Fibre	Ether Extract	Total ash	NFE	Ca	P
Extrusion	79.00	40.20	19.50	9.72	4.27	26.31	0.45	0.33
Cooked	89.83	39.27	12.51	19.27	4.39	24.56	0.56	0.29
Toasted	91.25	35.47	28.34	18.03	4.41	13.75	0.44	0.28
Roasted	90.57	37.53	24.29	16.92	4.46	16.8	1.08	0.29

Table 2: Composition of Experimental Diets

	Starter phase				Finisher phase			
	T1	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
Maize	4.00	41.45	44.35	42.25	45.00	41.70	48.60	46.60
Maize Bran	9.05	4.51	3.74	4.00	9.20	10.75	3.00	5.35
Rice Bran	3.00	2.59	0.10	1.00	2.10	2.10	-	0.10
Soya Extrusion	29.50	-	-	-	29.00	-	-	-
Soya Cooking	-	30.50	-	-	-	31.00	-	-
Soya Toasting	-	-	32.10	-	-	-	31.35	-
Soya Roasting	-	-	-	32.00	-	-	-	31.00
Blood Meal	4.00	4.00	4.50	4.00	3.00	2.50	2.75	3.00
Fish Meal	3.50	3.50	3.76	4.00	2.00	2.00	2.25	2.25
Bone Meal	4.50	5.00	4.50	4.00	4.00	4.00	4.50	4.25
Limestone	1.75	2.80	-	1.80	-	-	-	-
Palm Oil	1.75	2.70	4.00	4.00	2.75	3.00	4.50	4.50
L-Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
****Calculated**								
ME/Kcal/kg	3000.26	3000.50	3001.29	3009.00	3129.26	3100.00	3042.46	3094.23
CP%	24.10	24.13	24.00	24.03	22.21	22.00	21.61	22.25
Determined analysis								
D M (%)	92.69	92.87	92.73	92.72	93.43	92.95	92.83	92.62
CP (%)	22.00	21.77	23.47	20.53	20.83	22.99	20.12	20.41
CF (%)	4.75	6.40	7.36	7.60	7.15	5.19	6.94	7.26
EE (%)	10.48	13.40	12.72	12.11	12.42	10.59	14.47	13.44
T Ash (%)	14.75	15.19	15.1	12.55	9.31	9.96	9.68	9.44
NFE (%)	40.71	36.11	34.08	39.93	43.72	44.22	41.62	42.07

*Premix to provide the following per KG of diet: Vitamin A, 9,000 IU; Vitamin D3, 2,000,IU; vitamin E, 18 IU; vitamin B1, 1.8 mg; vitamin B2, 6.6 mg B2,; vitamin B3, 10 mg; vitamin B5, 30 mg; vitaminB6, 3.0 mg; vitamin B9, 1 mg; vitamin B12, 1.5 mg; vitamin K3, 2 mg; vitamin H2, 0.01 mg; folic acid, 0.21 mg;nicotinic acid, 0.65 mg; biotin, 0.14 mg; Choline chloride, 500 mg; Fe, 50 mg; Mn, 100 mg; Cu, 10 mg; Zn, 85 mg;I, 1 mg; Se, 0.2 mg.
** Calculated using feedwin software
DM (Dry Matter); CP (Crude Protein); CF (Crude Fibre); EE (Ether Extract); T Ash (Total Ash); NFE (Nitrogen Free Extract)

The performance parameters of broilers fed different thermally processed soyabeans diets are presented in Table 3. No significant (P<0.05) differences were observed in the initial body weight and average body weight in the starter phase while broilers fed cooked and toasted soyabeans diets had better body weight (2127.50 and 2197.50g), respectively when compared with the extrusion and roasted soya beans group whose values were 1853.33 and 1645.00g respectively. Significant ($P<0.05$) differences were observed in feed intake at both the starter and finisher phases. The highest feed intake value in the starter phase was 490.67 and 415.67g in cooked and toasted soyabean based groups while the least feed intake value was 186.67g for the roasted soyabean fed birds. Similarly, roasting gave the least feed intake (844.00, 902.33, 894.00g) respectively in the finisher phase.

The average body weight gain values were also significantly ($P<0.05$) different in both the starter and finisher phases. Roasting had the lowest body weight gain (186.67g) when compared with 210.33, 285.33 and 276.6g for extrusion, cooking and toasting respectively in the starter phase while the average body weight gain value for roasting in the finisher phase was lowest (337.33g) when compared with 466.67, 424.33, and 436.67g for extrusion, cooking and toasting respectively. FCR were significantly ($P<0.05$) different at the starter phase with roasting having the best FCR value of 1.41 whereas no significant ($P<0.05$) difference was observed in the FCR at the finisher phase. Similarly, the survival percentage values were significantly different only at the finisher phase with the highest survival percentage of 99.00% and the lowest value of 97.33%. Performance index was also significantly different at both the starter and finisher phases. The performance index values ranged between 112.88 and 177.07 in the starter phase and from 175.02 to 255.86 in the finisher phase.

The differences observed between the experimental phases and treatment groups in the performance evaluation traits especially in feed intake, weight gain, FCR and performance index were as a result of dietary nutrient intake and composition of the different thermally processed soyabeans diets which were influenced by high variation in trypsin inhibiting activities (TIA) reduction (5.44-85.02%) among thermal processing methods as well as age of birds. This was similarly reported by (20, 21, and 22) among other workers. The reduction in phytic acid may have significantly influenced FCR as roasting which had the highest reduction in phytic acid (4) gave the best results in the aforementioned indices.

Table 3: Effect of Thermal Processing of Soyabeans on Performance Parameter of Broilers

Processing Methods	Initial Body Weight	Average Body Weight	Feed Intake (g)	Average Body Weight Gain (g)	FCR	Survival (%)	Performance Index
Starter Phase							
Extrusion	47.67	537.60	374.00[a]	210.33[b]	1.78[c]	95.33	112.88[b]
Cooking	40.67	642.37	490.67[a]	285.33[a]	1.72[bc]	95.33	158.58[a]
Toasted	44.33	582.80	415.67[b]	279.67[a]	1.49[ab]	94.00	177.07[a]
Roasted	45.00	514.67	260.67[c]	186.67[b]	1.41[a]	94.00	125.89[b]
SEM	0.99NS	20.60NS	25.91*	13.28*	0.05*	0.76NS	8.43*
Finished Phase							
Extrusion	537.60	1853.33[b]	844.00[a]	466.67[a]	1.81	98.93[a]	255.86[a]
Cooking	642.37	2127.50[a]	902.33[a]	424.33[a]	2.13	98.67[a]	196.39[ab]
Toasted	582.80	2197.50[a]	894.00[a]	436.67[a]	2.05	99.00[a]	211.48[a]
Roasted	514.67	1645.00[c]	648.33[ab]	337.33[b]	1.97	97.33[b]	175.02[b]
SEM	20.60NS	68.21*	32.65*	17.66*	0.06NS	0.19*	12.73*

abc Means in the same column with the same superscript are not significantly (P>0.05) different
SEM=Pooled Standard Error of Means *=Significantly (P<0.05) different NS=Not Significant.

Table 4: Effect of Thermal Processing Methods of Soyabeans on Nutrient Digestibility in Broilers

Nutrient Digestibility (%)								
Processing Methods	Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Total Ash	NFE	Calcium	Phosphorus
Starter Phase								
Extrusion	71.10[b]	89.11	60.52[c]	89.42	71.72	95.90	87.63	84.27
Cooking	77.01[a]	85.94	87.93[a]	88.83	86.04	87.23	74.98	84.29
Toasted	73.42[ab]	86.07	88.06[a]	90.25	67.75	93.50	60.11	80.48
Roasted	57.50[c]	81.24	83.80[b]	76.71	77.67	95.89	83.31	87.24
SEM	2.28*	0.85NS	3.44*	1.68NS	2.08NS	1.07NS	3.17NS	0.72NS
Finished Phase								
Extrusion	85.01	83.03	67.88	92.80	65.53	93.14	97.52	68.40
Cooking	84.91	83.62	70.00	95.70	58.83	93.16	78.41	70.68
Toasted	85.00	81.86	69.87	95.82	34.07	92.45	92.67	68.60
Roasted	85.10	81.72	78.63	95.36	58.49	88.28	78.58	75.81
SEM	0.02NS	0.24NS	1.25NS	0.37NS	3.61NS	0.61NS	3.72NS	0.90NS

abc Means in the same column with the same superscript are not significantly (P>0.05) different
SEM=Pooled Standard Error of Means *=Significantly (P<0.05) different NS=Not Significant

The effect of thermal processing methods of soyabeans on the nutrient digestibility in broilers is presented in Table 4. The dry matter and crude fibre values showed significant (P<0.05) difference at the starter phase only while no significant (P>0.05) difference was observed in the digestibility of other nutrients at both the starter and the finisher phase.

The bio-economic implications of feeding broilers with different thermally processed soyabean based diets are presented in Tables 5 a, b and c as cost, benefit and gross profit Tables. Price per kilogramme feeds, metabolisable energy and crude protein at both starter and finisher phases were highest in toasting and lowest costs of the listed parameters were recorded in the extrusion group. The highest production cost value of N34, 209.60 was recorded in the toasting group while the least total cost of production was recorded in the roasting group with the total cost value of N29, 029.80. Total income value of N56, 870.00 was the highest figure recorded in the toasting group while roasting gave the least income of N41, 745.00. Gross profit of N16,079.50, N20,865.30, N22,660.40 and N12,715.20 were respectively recorded for extrusion, cooking, toasting and roasting while the benefit/cost ratio were as follows: 0.06, 0.62, 0.66 and 0.70 representing toasting, cooking, roasting and extrusion respectively.

Table 5: Cost/Benefit Analysis of the Effect of Thermal Processing Methods of Soyabean on the Performance of Broilers

A. Cost

Thermal Processing Methods				
Parameters	Extrusion	Cooking	Toasting	Roasting
Cost of Birds @ 200/DOC (N)	12,000	12,000	12,000	12,000
Housing Cost @ 50k/bird/day (N)	1,500	1,500	1,500	1,500
Brooding Cost	2,750	2,750	2,750	2,750
Drugs & Vaccines	912	912	912	912
Personnel Cost @ 200/man day	1,000	1,000	1,000	1,000
Total cost	18,162	18,162	18,162	18,162
Feed Cost				
Price/kg Starter Feed*	50.69	52.37	56.19	55.84
Price/kg Finisher Feed*	51.96	51.24	56.17	55.77
Price/ME Starter*	16.89	17.45	18.72	18.56
Price/ME Finisher*	16.55	16.56	18.46	18.00
Price/CP Starter*	2.10	2.17	2.34	2.32
Price/CP Finisher*	2.34	2.31	2.59	2.50
Feed Consumed Starter	374.00	490.67	415.67	260.67
Feed Consumed Finisher	844.00	902.33	894.00	648.33

Price/Feed Consumed Starter	18.96	25.70	23.36	14.56
Price//Feed Intake (5 wks)	94.80	128.50	116.80	72.80
Price/Feed Consumed Finisher	43.85	46.24	50.22	36.11
Price/Feed Intake (3 wks)	131.55	138.72	150.66	108.33
Cost of feed Consumed	226.35	267.22	267.46	181.13
Number of Birds Fed	60	60	60	60
Total Cost of Feed Consumed	13,581.00	16,033.20	16,047.60	10,867.80

* Calculated as output from Feedwin Software

B. Benefit				
Average Weight/bird	1.85	2.13	2.2	1.65
Cost/KG bird	550	550	550	550
Number of Birds Sold	47	47	47	46
Total Income	47,822.50	55,060.50	56,870.00	41,745.00

C. Cost				
Total Income	47,822.50	55,060.50	56,870.00	41,745.00
Total Cost	31,743.00	34,195.20	34,209.60	29,029.80
Gross Profit	16,079.50	20,865.30	22,660.40	12,715.20
Cost/Benefit	0.66	0.62	0.60	0.70

Conclusion and Applications

It was concluded that:

1. The thermal processing methods showed varied effects on both the chemical parameters measured and on the performance of the experimental broilers.
2. The overall best performance recorded in the cooking group indicated that cooking of soyabeans was the best thermal processing method that will guarantee the balance between performance and cost.
3. The poor performances recorded in the roasting group confirmed the process as not suitable soyabean processing method for broiler feeds.

Acknowledgements

The authors sincerely acknowledgement the support of Mr Sylvester and Mallam Aliyu of the Microbiology and Biochemistry Laboratories of the National Veterinary Research Institute (NVRI) Vom, Mr Yau Agade and Munir Mohammed of the College of Agriculture ,Lafia Animal Science Laboratory. The financial support received from FIMs services for this research is acknowledged.

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