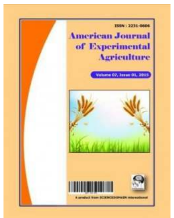

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The Potential of Jack Bean (*Canavalia ensiformis*) as a Replacement for Soybean (*Glycine max*) in Broiler Starter and Finisher Diets

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

This research study was carried out to evaluate the utilization of treated jack bean meal (JBM) and to determine its replacement value for soybean meal in broiler diets. Jack bean meal was incorporated at 0, 5, 10, 15 and 20% levels in both starter and finisher rations. A total of one hundred day old Ross broiler chicks were randomly allotted to five dietary treatments with two replicates in a completely randomised design (CRD). Parameters measured were daily feed intake, daily weight gain, feed conversion ratio, final live weight, carcass weight and internal organ weights. Gross examination of internal organs was also conducted. During 0-4 weeks of age, it was observed that as the level of JBM increased in the diets, there was significant (P<0.05) reduction in daily feed intake and daily weight gain among the dietary treatments. However, the feed conversion ratio was not significantly (P>0.05) affected by the dietary treatments. At the finishing phase of 5-9 weeks of age, daily feed intake was significantly (P<0.05) reduced as the inclusion level of JBM increased, while daily weight gain and feed conversion ratio showed no significant (P>0.05) difference between the control and other treatments, this observation may be due to tolerance of birds as they grew older. The experiment lasted for 9 weeks. Gross examination of the internal organs show no trace of macroscopic lesion, necrosis or haemorrhage among dietary treatments.

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Conclusively, it is possible to incorporate JBM up to 20% in broiler diet without deleterious effect on performance of broilers.

Keywords: Starter diet; finisher diet; jack bean; soybean; performance; unconventional protein sources.

1. INTRODUCTION

The escalating cost of feeding poultry has been majorly due to the high cost of the protein ingredients used in feed formulation. This situation has therefore, resulted to the increasing search for affordable and locally available alternative feed ingredients. Alternate protein sources are in demand by poultry feed industries in Nigeria, this is particularly due to the economic situation which limits the used of soybean (*Glycine max*) meal and groundnut (*Arachis hypogea*) cake. Soybean is among the major feed ingredients in poultry feeds, generally representing about 20-35% of the formulated diets (Oyawoye E. O. 1999 personal communication). Additionally, soybean along with groundnut also forms part of the staple food for humans in Nigeria. Consequently, the high cost of soybean is because of the demand of both human populace and livestock for this important legume seed.

Hence, there arise the need to exploit the nutritional and feeding potentials of other neglected and/or under-utilized novel plant protein sources to serve as possible alternatives, in view of the continuous demand and pressure on these conventional and traditionally used protein sources arising from increasing multiple uses. It has been well documented that the traditional or conventional feedstuffs used for compounding livestock feeds can longer sufficiently meet the needs of the fast growing livestock industry in Nigeria. Abubakar [1] mentioned that the sustainability of animal agriculture will be ensured by increasing the supply of livestock feedstuffs particularly from unconventional sources.

Canavalia ensiformis, an unconventional legume also known as jack bean, has great potential as a possible plant protein ingredient in animal feed. Jack bean has its origin in the western part of India and Central America [2]. Jack bean varieties, which are vigorous, exceptionally productive, large-seeded tropical legumes were originally grown in the drought ridden regions of Arizona and Mexico in ancient times and utilized as high-protein food and forage crops for many centuries by natives of Mexico, South Western United States, Central American countries, Peru, Ecuador, Brazil, West Indies, Bolivia, Paraguay and Argentina.

According to [3] jack bean has good nutritive quality for feed formulation and utilization. The proximate composition of jack bean as determined by [3] is presented in g/100g as crude carbohydrate 41.26, crude protein 24.32, crude fat 3.17, crude fibre 6.13 and ash 2.11. Abitogun and Olasehinde [4] reported that jack bean exhibits great potential for inclusion in animal diets based on their result findings of the proximate analysis and mineral composition of jack bean. Additionally, its nutritional quality is similar to some commonly used legumes. This quality makes it suitable for feeding poultry and other non-ruminants [5-12].

Canavalia ensiformis seeds can be used as an animal feed ingredient, since they are a good source of starch and protein [13]. However, in order to be used as an animal feed ingredient, *Canavalia ensiformis* seeds would have to be thermally processed in order to detoxify antinutritional factors present in the raw seeds. Heating denatures protein and makes them more susceptible to attack by digestive enzymes making them more available to the animal [14]. However, careful control of heating is essential to prevent functional as well as nutritional damage to proteins resulting from over heating.

2. MATERIALS AND METHODS

2.1 Procedure Employed in the Detoxification of Raw Seeds of Jack Bean

Raw dry seeds of jack bean were treated using the following procedure. Two percent (2%w/v) wood ash solution was prepared by dissolving 2 kg of wood ash in 100 litres of tap water, giving a ratio of 1:50 w/v. One hundred kilogram (100 kg) of jack bean seeds were then soaked in 300 litres of wood ash solution for 48 hours, at ambient temperature, with stirring taking place every 12 hours for 1-2 minutes. The ratio of jack beans to wood ash solution was 1:3 (w/v). The wood ash solution used in soaking the jack beans was discarded and the jack beans were rinsed with fresh tap water. Cooking of these beans in fresh 2% (w/v) wood ash solution was done for 90 minutes. The solution used in cooking the beans was drained off. The jack beans were rinsed again with fresh tap water, sundried and ground using hammer mill. The jack beans thus treated, was then used in the formulation of the experimental diets.

2.2 Experimental Design

A total of a hundred day-old Ross broiler chicks of Anak 2000 strain were used for the purpose of this experiment. Before commencement of the experiment the day old chicks were weighed and randomly assigned to five dietary treatments with two replications in a completely randomised design. Processed jack bean meal was included at 0, 5, 10, 15 and 20% levels in both the starter and finisher broiler diets (Tables 1 and 2). Diets formulated were isonitrogenous and isocaloric.

2.3 Birds and Management

Birds were raised on deep litter. The day old chicks were weighed and allocated randomly to five experimental diets. Feed and water were provided *ad-libitum* throughout the experimental period. Water troughs were washed daily before fresh water was served. During the feeding trial, the normal routine vaccination programme was followed.

2.4 Internal Organ Weights and their Gross Examination

At the end of the experiment, a total of thirty birds were used for gross examination of the internal organs. Six birds were used from each treatment group for the internal organs gross examination and internal organ weights. The heart, liver, lungs, pancreas, gizzard, spleen and intestine were weighed and expressed as a percentage of live body weight. Gross examination of these internal organs for macroscopic lesions, necrosis and haemorrhage were conducted.

2.5 Proximate Analysis

The proximate analyses of experimental starter and finisher diets (Tables 1 and 2) were carried out according to the methods of Association of Official Analytical Chemists [15].

Table 1. Composition of experimental starter diets (0-4 weeks)

Ingredient	(JBM) 0%	(JBM) 5%	(JBM) 10%	(JBM) 15%	(JBM) 20%
Maize	44.21	42.50	40.50	39.07	37.32
Jack bean meal	-	5.00	10.00	15.00	20.00
Soybean (full fat)	36.66	33.37	30.11	26.80	23.55
Maize bran	12.00	12.00	12.00	12.00	12.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Bone meal	1.78	1.78	1.78	1.78	1.78
Oyster shell	0.60	0.60	0.60	0.60	0.60
DL-methionine	0.25	0.25	0.25	0.25	0.25
Min/vit/premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analyses					
Crude protein	22.00	22.10	22.19	22.29	22.38
Metabolisable energy	3146.18	3125.32	3104.45	3083.60	3062.73
Proximate analysis					
Dry matter	90.52	90.60	90.84	90.50	90.70
Crude protein	23.06	22.56	23.06	22.94	22.40
Crude fibre	4.98	4.93	5.41	5.01	5.63
Ether extract	4.29	4.34	4.19	4.09	3.98
Ash	7.61	7.21	7.21	6.42	6.77

** Supplied per kg diet, the following:-*
Vitamin A, (5,000,000 I.U), Vitamin D3, (1,000,000 I.U), Vitamin E, (24.00 g), Vitamin K3, (1.00 g), Vitamin B1, (1.20 g), Vitamin B2, (2.80 g), Nicotinic Acid, (16.00 g), Calcium D-Panthothenate (4.00 g), Vitamin B6 (5.00 g), Vitamin B12, (16.00 mg), Folic Acid, (0.40 g), Biotin, (0.028 g), Choline Chloride, (120 g), Zinc Bacitracin, (16.00 g), Manganese, (40.00 g), Iron, (20.00 g), Zinc, (18.00 g), Copper, (0.80 g), Iodine, (0.62 g), Cobalt, (0.10 g), Selenium, (0.04 g)

Table 2. Composition of experimental finisher diets (5-9 weeks)

Ingredient	(JBM) 0%	(JBM) 5%	(JBM) 10%	(JBM) 15%	(JBM) 20%
Maize	46.71	45.00	43.26	41.57	39.82
Jack bean meal	-	5.00	10.00	15.00	20.00
Soybean (full fat)	36.66	33.37	30.11	26.80	23.55
Maize bran	13.00	13.00	13.00	13.00	13.00
Fish meal	0.50	0.50	0.50	0.50	0.50
Bone meal	1.76	1.76	1.76	1.76	1.76
Oyster shell	0.62	0.62	0.62	0.62	0.62
DL-methionine	0.25	0.25	0.25	0.25	0.25
Min/vit/premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analyses					
Crude protein	20.00	20.10	20.19	20.29	20.38
Metabolisable energy	3164.53	3143.76	3122.80	3101.96	3080.41
Proximate analysis					
Dry matter	90.75	91.14	91.04	90.98	91.65
Crude protein	20.06	20.25	19.88	20.31	20.44
Crude fibre	4.88	4.96	5.04	5.16	5.03
Ether extract	4.20	4.41	4.27	4.06	3.87
Ash	6.16	6.79	6.29	6.15	5.95

** Supplied per kg diet, the following:-*
Vitamin A, (5,000,000 I.U), Vitamin D3, (1,000,000 I.U), Vitamin E, (24.00 g), Vitamin K3, (1.00 g), Vitamin B1, (1.20 g), Vitamin B2, (2.80 g), Nicotinic Acid, (16.00 g), Calcium D-Panthothenate (4.00 g), Vitamin B6 (5.00 g), Vitamin B12, (16.00 mg), Folic Acid, (0.40 g), Biotin, (0.028 g), Choline Chloride, (120 g), Zinc Bacitracin, (16.00 g), Manganese, (40.00 g), Iron, (20.00 g), Zinc, (18.00 g), Copper, (0.80 g), Iodine, (0.62 g), Cobalt, (0.10 g), Selenium, (0.04 g)

2.6 Statistical Analysis

All the data obtained were subjected to the analysis of variance [16]. When analysis of variance indicated a significant treatment effect, means were separated using the Duncan's multiple range test [17].

3. RESULTS AND DISCUSSION

3.1 Daily Feed Intake

There were significant differences (P<0.05) among the dietary treatment in daily feed intake for broilers in the starting phase of 0-4 weeks of age. Daily feed intake was significantly reduced (P<0.05) at 20% level of inclusion of jack bean meal but the other dietary treatments were not significantly (P>0.05) different from each other (Table 3). Results on the daily feed intake of birds for 5-9 weeks showed that birds in the control group, that received 0% JBM were not significantly (P>0.05) different from those that received 5%, 10% and 15% JBM in their diets. Birds on 15% JBM diet recorded a value of 118.79g/day, which was not significantly different from the value of 109.46 g/day for birds on 20% JBM (Table 4).

Daily feed intake of broilers were significantly (P<0.05) influenced by dietary treatments during the starting phase (0-4 weeks) and finishing phase (5-9 weeks). This result however, contradicts the findings of [18] who reported no significant (P>0.05) difference in the daily feed intake. However, results obtained from the present study on daily feed intake agree with those of [19-21]. The daily feed intake of birds that received the 5%, 10% and 15% JBM diets were not significantly (P>0.05) different from the control. It was noticeable that the daily feed intake of birds was reduced as the inclusion level of JBM increased in the diets. The reduction in daily feed intake was observed to be particularly marked at 20% inclusion level of JBM. The reduction in daily feed intake may be caused by the unpalatable nature of jack bean. Probably it was at 20% inclusion level of JBM that birds became sensitive to the unpalatability of jack bean and thus responded by a drastic fall in feed intake.

3.2 Daily Weight Gain

On one hand, the daily weight gain of broilers fed graded levels of jack bean meal during the starter phase (0-4 weeks) was significantly (P<0.05) affected by dietary treatments. The weight gains of birds were significantly reduced as the inclusion level of jack bean meal increased in the diet (Table 3). Birds fed the 0% JBM diet had the highest daily weight gain of 26.71 g/day while birds on the 20% JBM diet had the lowest daily weight gain of 19.24 g/day.

On the other hand, the daily weight gain of birds during the finishing phase of 5-9 weeks was not significantly (P>0.05) different among the dietary treatments (Table 4). The daily weight gain ranged from 44.67 g/day for birds on the 20% JBM diet to 52.96 g/day for those on the 10% JBM diet.

Daily weight gain was significantly (P<0.05) affected by the dietary treatments during the starter phase (0-4) of the feeding trial. The daily weight gain of birds in the control group (0% JBM) was not significantly different from those of the birds fed 5%, 10% and 15% JBM diets. The reduction in daily weight gain as the inclusion level of JBM increased in the diets during this period (0-4 weeks) was paralleled by a fall in daily consumption of feed, suggesting that the gradual decrease in growth rates was as a result of low rates of feed consumption. Kessler et al. [8] made similar report when they fed autoclaved jack beans to birds.

Daily weight gain of broilers showed no significant (P>0.05) variation among the dietary treatment at 5-9 weeks of age. Therefore, it could be explained that as birds grew older they were able to gain weight despite the reduction in feed intake observed during this period of the feeding trial. This result is indicative of the success achieved in eliminating growth retarding factors in jack bean. This confirmed the findings of [18] who reported a non-significant (P>0.05) effect on daily weight gain of broilers fed two-stage cooked jack bean. The present finding is, however, contrary to the reports of [22] who stated that daily weight gain was significantly (P<0.05) influenced by dietary treatments. D'Mello et al. [19] also reported a highly significant reduction (P<0.01) in daily weight gain. Differences in the response of birds to high levels of JBM as reported by different researchers may be due to the method employed in the detoxification of raw jack beans used in their experiment. This is because some methods may not result in complete inactivation of the growth retarding factors found in jack beans.

Table 3. Effect of graded levels of Jack Bean Meal (JBM) on performance parameters of broilers from 0 to 4 weeks of age

Performance parameters	Dietary level of Jack Bean Meal (JBM)					
	0% JBM	5% JBM	10% JBM	15% JBM	20% JBM	SEM
Daily feed intake (g/day/chick)	39.49^{a}	39.76^{a}	38.00^{a}	37.38^{a}	32.37^{b}	±0.85
Daily weight intake (g/day/chick)	26.71^{a}	26.52^{a}	23.12^{ab}	22.73^{ab}	19.24^{b}	±1.18
Feed conversion ratio (g.feed/g.gain)	1.48	1.50	1.65	1.65	1.69	±0.10

Means followed by different superscript letters in the same row differ significantly to P≤0.05

Table 4. Dietary influence of graded levels of Jack Bean Meal (JBM) on performance parameters of broilers from 5 to 9 weeks of age

Performance parameters	Dietary level of Jack Bean Meal (JBM)					
	0% JBM	5% JBM	10% JBM	15% JBM	20% JBM	SEM
Daily feed intake (g/day/chick)	126.07^{a}	128.54^{a}	129.68^{a}	118.79^{ab}	109.46^{b}	±3.03
Daily weight gain (g/day/chick)	51.68	51.65	52.96	48.14	44.67	±1.98
Feed conversion ratio (g.feed/g.gain)	2.45	2.49	2.45	2.47	2.45	±0.08
Final live weight (g)	2591.20	2585.90	2536.30	2357.50	2142.50	±85.40
Carcass weight (g)	1691.70	1675.00	1625.00	1416.70	1400.00	±80.20

Means followed by different superscript letters in the same row differ significantly to P≤0.05

3.3 Feed Conversion Ratio

Feed conversion ratio of broilers at 0-4 weeks was not significantly (P>0.05) influenced by the dietary treatments. The feed conversion ratio of birds ranged from 1.48 for the 0% JBM diet to 1.69 for the 20% JBM diet (Table 3). There was no significant (P>0.05) difference in the feed conversion ratio of birds during 5-9 weeks of the feeding trial. The feed conversion ratio ranged from 2.45 for birds on the 0%, 10% and 20% to 2.49 for birds on the 5% JBM diets (Table 4).

Feed conversion ratio of birds for 0-4 weeks and 5-9 weeks of the feeding trial showed no significant (P>0.05) difference among the dietary treatments. Interestingly, the statistically similar feed conversion ratio recorded for all the dietary treatments at various growing phases and throughout the experimental period, suggests that all diets were equally efficient for weight gain. Birds demonstrated the ability to efficiently utilize jack bean meal in their diet. This result is in agreement with the findings of [22] that fed autoclaved jack beans to broilers and obtained similarity in their feed conversion ratio. Kessler et al. [8] also reported that the feed conversion ratio of birds that received autoclaved jack bean was not significantly (P>0.05) different from that of the control group. Udedibie et al. [18] fed two-stage cooked jack beans to broilers and found that feed conversion ratio of birds exhibited a non-significant (P>0.05) effect among dietary treatments.

3.4 Final Live Weight and Carcass Weight (Dressed Weight)

The final live weight of birds showed no significant (P>0.05) variation among the dietary treatments. This was in line with the reports of [8]. Carcass weight followed a similar trend as observed in the final live weight with dietary treatment effect not being statistically significant (P>0.05). Broilers on the 0% JBM diet had the highest weight of 1691.70 g while those on the 20% JBM diet had the lowest value of 1400.00 g (Table 4). It was evident that irrespective of the dietary treatments, birds were able to utilize jack bean effectively for gains in weight.

3.5 Internal Organ Weights (as a Percentage of Body Weight)

The weight of the internal organs of broilers showed insignificant (P>0.05) difference among the dietary treatments (Table 5). Sometimes, the weight of the internal organs such as the heart, liver, lungs, pancreas, gizzard, spleen and intestine is measured to examine the effect of the test ingredients on the recipient animal [23]. Nesheim and Garlich [24] Demonstrated that birds are particularly sensitive to anti-nutritional factors even over short periods. Trypsin inhibitor has been implicated as one of the factors capable of reducing protein digestibility and inducing pancreatic hypertrophy [25]. It is generally acknowledged that hepatic hypertrophy implicates canavanine as one of the casual agents since, being an analogue of arginine, canavanine can act as an antagonist in the normal production of liver protein, impairing liver function and producing a hypertrophic effect [26]. It is therefore, clear that the absence of hypertrophic effect on the pancreas and liver suggests the complete inactivation of trypsin inhibitor and canavanine respectively. It is evident that there was normal protein digestion and protein synthesis.

3.6 Gross Examination of Internal Organs

Gross examination for macroscopic lesions, necrosis and haemorrhage made on the heart, liver, lungs, pancreas, gizzard, spleen and intestine showed no trace of lesions, necrosis or haemorrhage in any of the internal organs

Table 5. Dietary Influence of varying levels of Jack Bean Meal (JBM) on the relative internal organ weights of broilers

Internal organs (% body weight)	Dietary level of Jack Bean Meal (JBM)					
	0% JBM	5% JBM	10% JBM	15% JBM	20% JBM	SEM
Gizzard	1.89	1.84	1.92	1.93	1.57	±0.14
Liver	1.97	1.84	1.93	1.74	2.00	±0.11
Heart	0.44	0.36	0.52	0.35	0.46	±0.10
Pancreas	0.26	0.22	0.28	0.19	0.27	±0.02
Lungs	0.67	0.55	0.56	0.51	0.61	±0.04
Spleen	0.14	0.10	0.16	0.12	0.15	±0.02
Intestine	3.50	3.52	3.44	3.59	3.41	±0.14

examined for all the different dietary treatments. Kessler et al. [8] reported that the absence of lesions on the small intestine suggests the elimination of lectins (haemagglutinins) during cooking of jack beans. The susceptibility of anti-nutritional factors to thermal inactivation was apparent from the absence of lesions in birds fed jack bean meal at varying inclusion levels. It is therefore possible that a complete inactivation of residual toxic effects was achieved and thus proving the efficacy of the method employed in detoxifying jack beans.

4. CONCLUSIONS

Based on the outcome of this research study, it is possible to use JBM in both starter and finisher broiler diets up to the inclusion level of 20% without negatively affecting broiler performance. Hence, it is worth noting that processed jack bean meal has great potential for utilization in formulating poultry feeds in the future if properly exploited. They may be particularly required or used where conventional protein sources are either expensive or not readily available. This result shows that the procedure employed in this research for detoxifying jack bean was successful and effective. Future research may be carried out on other poultry birds and in addition, further study may be conducted on possible methods of improving the palatability of *Canavalia ensiformis* seeds for enhancing feed intake in poultry.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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