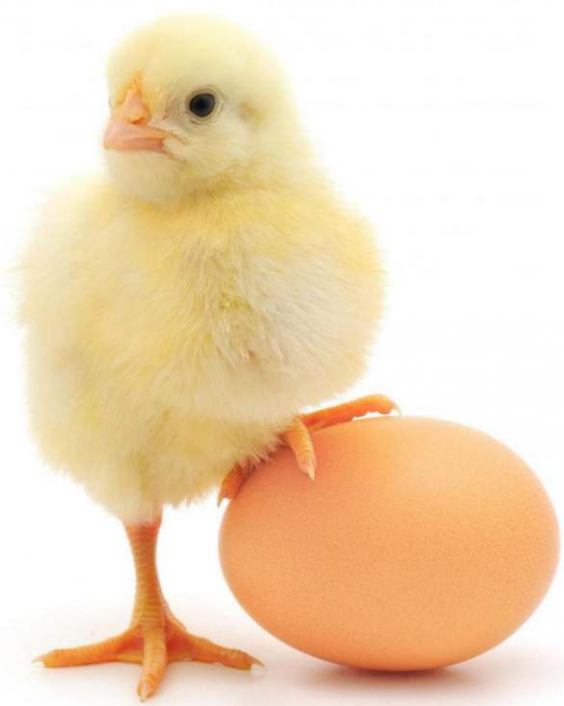
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 9 (12): 1092-1096, 2010
ISSN 1682-8356

Effect of Dietary Levels of Toasted Mucuna Seed Meal (TMSM) on the Performance and Egg Quality Parameters of Laying Japanese Quails (*Coturnix coturnix japonica*)

C.D. Tuleun and N.A. Dashe
Department of Animal Nutrition, University of Agriculture, Makurdi, Nigeria

Abstract: A 8 week feeding trial was conducted to determine the effect of dietary inclusion of Toasted Mucuna Seed Meal (TMSM) on the performance and egg qualities of Japanese quail layers. Four (4) isonitrogenous (20% cp) diets were formulated to contain toasted mucuna seed meal at 0, 5, 10 and 15%. Each of the dietary treatments was triplicated with 10 birds per replicate (making a total of 120 birds for the experiment) in a completely randomized design. The birds were offered feed and water *ad libitum*. The results showed that the quail layers fed up to 15% dietary levels of TMSM had percent hen-day and hen housed egg production, average feed intake, feed intake per egg production and feed intake per gram egg production values that were not statistically different (p>0.05) from those fed the 0% TMSM (control) diet. Albumen width and shell thickness were significantly (p<0.05) lowered by the increasing levels of TMSM, while egg circumference and all yolk parameters were not affected significantly (p>0.05). Dietary inclusion of TMSM at all levels reduced feed cost which was also reflected in feed cost per egg produced and feed cost per bird produced. Therefore the use of TMSM as a feed ingredient up to 15% level in quail layer diets is profitable, feasible and desirable.

Key words: Toasted mucuna seed meal, feed ingredient, quail layer, performance and egg qualities

INTRODUCTION

Low protein consumption in the developing nations including Nigeria as a result of poverty and over population has encouraged greater interest in the production of fast growing farm animals. Poultry production has been seen as a major strategy of bridging the animal protein gap to the teeming populace within short-run considerations (Dafwang, 1990). Poultry is popular because when compared with the beef industry for example, it enjoys a relative advantage of easy management, higher turnover, quick returns to capital investment and a wide acceptance of its products for human consumption (Haruna *et al*., 1997; Edache *et al*., 2007). Japanese quails as an important animal protein source have caught the attention of scientists and researchers in the recent times (Edache *et al*., 2005). Quails are highly prolific and hardy (Anon, 1991) which make them adaptable to the tropical environment. They mature in about 6 weeks and are usually in full egg production by 50 days of eggs, with hens laying up to 200-300 eggs in their first year of lay (NRC, 1991; Smith, 2001). The meat is lean and the egg is low in cholesterol (Agwuonobi and Ekpenyong, 1990; Okon *et al*., 2007) indicating its significance in public health in terms of conditions like atherosclerosis.

Some of the major constraints in poultry production are the irregular supply of conventional feeds-stuffs especially protein feedstuff and disproportionate high cost of feed. Efforts should therefore be directed towards exploiting feed resources that are cheap, available and not in direct us by humans and other industrial users. Legumes offer a good array of possible sources.

Velvet bean *(Mucuna utilis)* is a tropical legume that is little known and used as a human food or animal feed. It yields heavily in seed and forage in the humid tropics of Nigeria (Emenalom and Udedibie, 2005). The crude protein of the dried seed ranged from 24-32% on dry matter basis and is of relatively good amino acid profile (Udedibie and Carlini, 1998; Del Carmen *et al*., 1999). Siddhuraju *et al.* (1996) also reported energy content of 16,565 $kJkg^{-1}DM$. However, velvet beans like most tropical legumes contain high contents of toxic and antinutritional factors (Udedibie and Carlini, 1998; Ukachukwu *et al*., 1999a,b; Carew *et al*., 2002; Tuleun and Patrick, 2007) which affects there acceptability and utilization. Studies on the nutritive value of the bean have shown that the raw bean depresses growth in broilers (Olaboro *et al*., 1991; Emenalom and Udedibie 1998; Del Carmen *et al*., 1999) and reduced egg production in laying hens (Harms *et al*., 1961; Iyayi and Taiwo, 2003). Elimination or reduction of some of the effects of these toxic factors can be achieved by thermal treatments thereby making the constituent nutrients more biologically available. This study was therefore conducted to assess the effect of *Mucuna utilis* subjected to a locally adaptable thermal treatment (toasting) method on the performance of laying Japanese quails.

Corresponding Author: C.D. Tuleun, Department of Animal Nutrition, University of Agriculture, Makurdi, Nigeria

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of the University of Agriculture, Makurdi (07°41'N, 08°37'E), Benue State located in the Southern Guinea Savanna Zone of Nigeria.

Seeds of *Mucuna utilis* were acquired from the International Institute of Tropical Agriculture (IITA), Ibadan. These seeds were cleaned of dirt and subjected to toasting; a process which involved spreading of the seeds thinly in preheated sand inside a frying pan for 30 min at a temperature fluctuating between 90-100°C. The contents were stirred continuously to ensure uniform heating. The toasting was considered adequate when the seeds changed from light yellow to light brown and also become crispy to touch with a "beany" smell. After toasting, the seeds were removed by sieving the hot sand, cooled and later ground to the desired particle size to produce the meal used. Four (4) isonitrogenous quail layers diets (20% crude protein) were formulated incorporate the Toasted Mucuna Seed Meal (TMSM) at the different levels of 0, 5, 10 and 15% respectively (Table 1).

A total of one hundred and twenty (120) healthy 6-weeks old Japanese quails *(Coturnix coturnix japonica)* were purchased from the poultry farm of the National Veterinary Research Institute Vom, Nigeria. They were randomly allotted to four (4) dietary groups each containing thirty (30) birds each in a completely randomized design. The treatments were triplicated with ten (10) birds each and housed in wire screened pens of 164 x 83 x 183 cm. All the birds were fed and watered *ad-libitum* under identical environmental and management conditions. The experiment lasted 8 weeks.

The performance characteristics of the birds determined included hen-day egg production, hen-housed egg production and feed intake and feed conversion ratio. Feed cost per kilogram diet was calculated using the prevailing market prices of feed ingredients. Mortality was recorded as it occurred.

During the 8 weeks of study, 60 eggs per treatment (20 per replicates) were collected fortnightly and used for the determination of egg quality (internal and external) characteristics.

Egg weight: Eggs were weighed using a mettler electronic balance.

Egg width: This was measured at the equator using a Vernier sliding caliper for the determination of internal egg quality traits. Each egg was broken on a flat transparent glass plate using a table knife to carefully crack the shell without breaking the vitelline membrane that enclosed egg yolk.

Albumen height: This was obtained by measuring the widest expanse of the thick albumen between the yolk edge and the external edge of the thick albumen.

Table 1: Composition of experimental diets with graded level of TMSM

	Inclusion level of TMSM (%)			
Ingredients	0	5.0	10.0	15.0
Maize	45.64	44.30	42.96	41.62
Full fat soyabean	17.93	16.10	14.27	12.44
Groundnut cake	17.93	16.10	14.27	12.44
Maize offal	10.00	10.00	10.00	10.00
Mucuna seed meal	0.00	5.00	10.00	15.00
Bone meal	3.00	3.00	3.00	3.00
Oyster shell	4.50	4.50	4.50	4.50
Common salt	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Vitamin/mineral premix*	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Crude protein (%)	20.00	20.00	20.00	20.00
Met. Energy (Kcal/kg)	2881	2880	2875	2876
Crude fibre (%)	4.00	4.17	4.34	4.48
Calcium (%)	2.77	2.86	2.94	3.03
Avail Phosphorus (%)	0.64	0.67	0.69	0.70
Feed cost (N/kg feed)[a]	75.45	71.41	67.36	63.31

*Premix supplied per kg ration: Vitamin A 10,000 Iu; Vit B3 2500 Iu., Vit. K.O.002 g, Vit B1 0.001 g; Vit B2 0.0045 g; Vit B6 0.003 g, Nicotinic acid 0.025 g; Calcium D. pantothenate 0.01 g; Vit Biz 0.12 g; folic acid 0.0003 g; Vtc. 0.05 g, choline chloride 0.30 g, manganese 0.1 g iron 0.05 g; zinc 0.045 g; copper 0.002 g; Iodine 0.001 g; cobalt 0.00023 g; selenium 0.001g. [a]Calculated from the prevailing market prices of the feeding stuff as at June, 2009

Yolk width: Yolk width was taken as diameter with pair of Vernier caliper.

Yolk height: Yolk height was measured by inserting a thin glass rod into the centre of the yolk and the height estimated using rule.

Yolk weight: Yolk weight was measured by carefully separating the yolk from the albumen using a plastic egg separator and then weighed individually with an electronic sensitive balance to the nearest 0.01 g.

Albumen width: Albumen width was measure to the nearest 0.1 cm using a Vernier caliper.

Egg shell thickness: Egg shell thickness was measured by air drying the individual egg shells for 72 h in the egg trays, then the thickness of the individual egg shell was measured at three different points (the narrow, mid point and broad ends) with a micrometer screw gauge to the nearest 0.01 mm. The mean of the three measurements were taken as the shell thickness.

Yolk colour: Yolk coluor was scored for individual egg yolk by comparing the colour of the yolk with the colour of the chips of a Hoffman-La-Roche yolk colour fan.

Data from the study were subjected to Analysis of Variance (ANOVA) using the Completely Randomized Design and treatment means which differed ($p<0.05$) significantly were separated using Duncan's New Multiple Range Test as outlined by Obi (2002).

RESULTS AND DISCUSSION

The performance of laying quails fed the various dietary inclusion of toasted mucuna seed meal is presented in Table 2. Inclusion of toasted mucuna in diets at 5-15% levels did not significantly (p>0.5) affect egg production as depicted by the hen-day and hen-house egg production. Birds in the control group 0%TMSM (maize-soy/groundnut cake based diet) had the highest hen day egg production (77.20%) and hen-housed egg production (76.39%) though these were not statistically different from the mucuna diets. This implies that toasted mucuna seed meal inclusion of up to 15% in the quail layers diet could serve as a replacement of protein source without any adverse effect on these parameters. This shows concordance with earlier findings of Iyayi and Taiwo (2003) and Tuleun *et al.* (2008) that laying hens fed 10% and 20% toasted mucuna seed meal respectively had similar hen performance to the control diet. They opined the similar responses by the birds to the reduction of antinutritional factors in the processed mucuna was buttressed by the fact that mucuna is high in protein and has fairly comparable sulphur amino acid and mineral content with soybean. Methionine has been reported to influence egg production and egg size of laying hens (Bamgbose and Biobaku, 2003). No significant (p>0.05) difference was observed between the daily feed intake of the control group and the mucuna dietary treatment groups. The daily feed intake per bird ranged between 22.94 g and 18.67 g while feed intake per egg production ranged between 34.93-29.77 g. These values decreased insignificantly with increased inclusion level of toasted mucuna seed meal. The depressed feed intake of birds on toasted mucuna diets may be attributed to the marginal effects of heat on antinutritional factor contents. Carew *et al.* (2003) Del Carmen *et al.* (1999;2002) Iyayi and Taiwo (2003) and Tuleun *et al.* (2008) have also reported that heat treatment can inactivate, reduce or completely destroy antinutritional components in velvet bean as though evidenced in the comparable feed intake of birds on mucuna and the control diets. The experimental diets did not have any significant effect (p>0.05) on Feed Conversion Ratio (FCR) in laying quails as the dietary level of mucuna increased. This indicates that toasting is an effective antidote and could possibly convert mucuna to an ingredient that is equivalent to properly processed soybean. It has been documented that the nutritive quality of a feedstuff is measured by its ability to released nutrients for maintenance and productivity of the animals (Oluyemi and Roberts, 2000). Ukachukwu (2000) Iyayi and Taiwo (2003) and Tuleun *et al.* (2008) have also observed a similar effect with layers fed toasted mucuna diets. Generally heat treatments have been reported to improve nutrient utilization of legumes by animals (Friedman *et al.*, 1991; Ologhobo *et al.*, 1993). Through out the experimental period, three birds from the control diet died. This mortality was not associated to the dietary content of mucuna seed meal. Lack of mortality among the quail layers fed toasted mucuna confirms that toasting was effective in detoxifying antinutritional constituents to safety level.

The dietary inclusion of the graded levels of toasted mucuna seed meal (0-15%) put the cost per kilogramme of feed, cost of feed per egg produced and cost of feed per bird produced at ₦75.45-₦63.31, ₦2.62-₦2.23 and ₦96.35-₦78.41 in diets 1-4 respectively. These values were progressively lowered or represent cost savings as the dietary levels of mucuna seed meal increased. The general reduction in cost of feed required to produce an egg as exemplified by the results of the mucuna diets support the submission of Mc Nab and Shannon (1994) and Nworgu *et al.* (1999). These authors highlighted the need for dietary formulation which can be used as an alternative non-competitive and cheap ingredient which can partly replace the conventional energy and protein feedstuffs in poultry diets. According to Fanimo *et al.* (2007) the best ration from the biological point of view is determined by the highest yield per unit feed consumed regardless of the feed consumption level. However, in terms of economic efficiency, diets that give the same out put at least cost are the most desired. In this trial dietary inclusion of toasted mucuna seed meal resulted in least cost diets and had least cost per egg produced (₦2.36 v ₦2.62 v ₦2.26 v ₦2.23/egg) and cost of feed per bird (₦96.35 v ₦95.72 v ₦83.37 v ₦78.41/birds).

Table 2: Performance of laying quails fed graded levels of TMSM diets

	Inclusion levels of TMSM (%)				
Parameters	0.0	5.0	10.0	15.0	SEM
Hen-day egg production (%)	77.20	65.25	65.82	62.71	6.662[NS]
Hen-housed egg production (%)	76.39	65.25	65.82	62.71	6.62[NS]
Average daily intake (g)	22.94	22.79	19.85	18.67	2.94[NS]
Average egg weight (g)	9.54	9.43	9.08	8.65	0.34[NS]
Feed intake/egg produceds	30.18	34.93	30.16	29.77	2.77[NS]
Cost of feed (₦/g)	0.075	0.071	0.067	0.063	
Cost of feed/egg produced (₦)	2.26	2.62	2.26	2.23	
Cost of feed/bird (₦)	96.35	95.72	83.37	78.41	

TMSM: Toasted Mucuna Seed Meal; SEM: Standard Error Mean; ₦: Nigeria Currency, Naira;
₦ 152: Equivalent to one US Dollar (Year June, 2009 exchange rate)

Table 3: Egg quality parameters of laying Japanese quails fed graded dietary levels of TMSM

	Inclusion levels of TMSM (%)				
Parameters	0.0	5.0	10.0	15.0	SEM
Egg weight (g)	9.54	9.43	9.08	8.65	0.34^{NS}
Egg Circumference (cm)	1.98	1.98	1.94	1.92	0.26^{NS}
Yolk width (cm)	1.79	1.84	1.94	1.72	0.096^{NS}
Yolk weight (cm)	0.62	0.59	0.61	0.57	0.034^{NS}
Yolk weight (kg)	2.95	3.14	2.94	2.61	1.15^{NS}
Yolk index	0.35	0.32	0.31	0.33	0.12^{NS}
Yolk colour	1.00	1.00	1.00	1.00	-
Albumen height (cm)	0.06	0.06	0.06	0.05	0.005
Albumen width (cm)	2.77^{a}	2.77^{a}	2.62^{a}	2.29^{a}	0.108*
Shell thickness (mm)	0.27^{a}	0.24^{b}	0.26^{a}	0.25^{ab}	0.0004*

^{ab}Means on the same row with different superscripts are significantly different ($p<0.05$);
SEM: Standard Error of Mean; TMSM: Toasted Mucuna Seed Meal

Table 3 shows that the different diets affect the egg quality characteristics differently. The control diet promoted the greatest egg weight (9.54 g) which was not significantly (p>0.05) different from the other diets while the 15 % TMSM gave the least egg weight (8.65 g). Egg circumference values followed a similar pattern as the egg weight values.

Yolk height, yolk width and yolk weight were not significantly (p>0.05) affected by feeding toasted mucuna diets. Similarly albumen height was not significantly influenced by feeding mucuna diets although albumen width was significantly (p<0.05) least in diet with 15% mucuna. The shell thickness was non-significantly (p>0.05) highest in the control diet followed by the group fed 10, 15 and 5% mucuna meal diets. The yolk colour was identical across the treatments. Results demonstrate that feeding toasted mucuna diet did not influence the external and internal egg quality characteristics. Similar observations have been made by Iyayi and Taiwo (2003) on processed mucuna seed meal on egg qualities of laying hens.

Conclusion: From the result obtained, it can be inferred that dietary inclusion of toasted mucuna seed meal up to 15% is comparable in performance with a conventional diet. No statistically significant difference (p>0.05) was observed in birds' performance by using this material up to this level in quail layer diets. However, it is not worthy that the use of this material in quail layer diets up to the 15% level resulted in 1.33% and 18.61% monetary savings in the cost of feed per egg produced and cost of feed per bird used in the production process respectively. This represent significant contribution from the use of this ingredient in quail layer diets especially where economics of scale are considered.

REFERENCES

Agwuonobi, L.N. and T.E. Ekpenyong, 1990. Nutritive and economic values of raising guinea fowls in Nigeria. J. Food and Agric., 52: 301-308.

Anonymous, 1991. Little known animals with promising Economic future (Micro-livestock) Board of Science and Technology for International Development, National Academy Press, Washington D.C., pp: 147-155.

Bamgbose, A.M. and W.O. Biobaku, 2003. Utilization of cotton seed cake as replacement for groundnut cake in layers diet: performance and egg quality characteristics. J. Pure and Applied Sci., 3: 140-148.

Carew, L.B., M.T. Valverde, E.I. Zakrzewska, F.A. Alster and A.G. Gernat, 2002. Raw velvet beans (*Mucuna Pruriens*) and L-dopa have differing effect on organ growth and blood chemistry when fed to chickens. Processing of the International Workshop. Food and Feed from Mucuna: current uses and the way forward". Tegucigalpa. Honduras, April 2000, pp: 272-287.

Carew, L.B., D. Hardy, J. Wels, F. ALster, S.A. Mischler A. Gernant and E.I. Zakrzewska, 2003. Heating raw velvet beans (*Mucuna Pruriens*) reverses some anti-nutritional effects on organ growth, blood Chemistry and Organ Histology in growing chickens. Trop. and Sub-tropical Agroeco System, 1: 267-275.

Dafwang, I.I., 1990. Poultry Production in Nigeria. A paper presented at workshop organized by the College of Agriculture, Lafia, Nigeira 1990.

Del Carmen, J., A.G. Gernat, R. Myhrman and L.B. Carew, 1999. Evaluation of raw and heated velvet beans. (*Mucuna pruriens*) as feed ingredients for broilers. Poult. Sci., 78: 866-872.

Del Carmen, J., A.G. Gernat, R. Myhrman and L.B. Carew, 2002. Evaluation of raw and heated velvet beans (*Mucuna pruriens*) as feed ingredients for broilers. In Milton Flores B., M. Eilitta, R. Myhrman, L.B. Carew and R.J. Carsky (Eds). Proceeding of International Workship on Food and Feed from Mucuna: Current Uses and Way Forward. Held in Tegucigalpa, Honduras. April, 26-29, 2002. CIDICCO, CIEPCA, pp: 258-271.

Edache, J.A., U. Musa, E.S. Haruna, P.D. Karsin, J.O. Esilonu and I.I. Jibrin, 2005. Calcium requirement of Japanese quail (*Conturnix conturnix Japonica*) chicks in plateau state, Nigeria. Nig. J. Anim. Prod., 32: 246-252.

Edache, J.A., Musa, P.D. Karsin, J.O. Esilonu, A. Yisa E.J. Okpala and N.J. Zwando, 2007. The Feeding value of Cassava meal Diets for Growing Japanese Quail (*Coturnix coturnix japonica*). Nig. J. Anim. Prod., 34: 77-82.

Emenalom, O.O. and A.B.I. Udedibie, 1998. Effect of dietary raw, cooked and toasted Mucuna Pruriens seed (velvet bean) on the performance of finisher broiler. Nig. J. Anim. Prod., 25: 115-199.

Emenalom, O.O. and A.B.I. Udedibie, 2005. Evaluation of different heat processing methods on the nutritive value of *Mucuna Pruriens* (Velvet bean) seed meal for broilers. Int. J. Poult. Sci., 4: 545-548.

Fanimo, A.O., A.J. Adebayo, O.O. Oduguwa and W.O. Biobaku, 2007. Feeding value of cashewnut testa for broiler chickens. Nig. J. Anim. Prod., 34: 83-93.

Friedman, M., D.L. Brandon, A.H. Babes and T. Hymowitz, 1991. Effects of heat on the nutritional quality of soybean cultivars. In: (Friedman, M. Ed) Nutritional and Toxicological consequences of food processing. Plenum Press New York, pp: 339-361.

Harms, R.I., C.F. Sampson and P.W. waldroup, 1961. Influence of feeding various levels of velvet bean to chicks and laying hen. J. Nutr., 75: 127.

Haruna, E.S., U. Musa, P.A. Okewole, D. Shemaki, L.H. Lombin, J.U. Molokwu, J.A. Edache and P.D. Karsin, 1997. Protein requirement of quail chicks in plateau state, Nigeria. Nig. Vet. J.,18: 108-133.

Iyayi, E.A. and V.O. Taiwo, 2003. The effect of diets incorporating Mucuna (*Mucuna Pruriens*) seed meal on the performance of laying hens and broilers. Tropical and Subtropical Agroeco system, 1: 239-246.

Mc Nab, B.N. and D.W.F. Shannon, 1994. The Nutitive value of Barley, Maize and Oats, Br. Poult. Sci., 15: 516-657.

NRC, 1991. Quail, in: Microlivestock-little know small Animals with a Promising economic future. National Academy Press Washington. D.C., pp: 147-155. National Research Council.

Nworgu, F.C., G.N. Egbunike, E.A. Iyayi, A.M. Adetoro and J.B. Fapohunda, 1999. Effects of replacement of groundnut cake with full fat extruded soybean meal on broiler performance In: the Nigeria Livestock Industry in the 21st century. Edited by Ologhobo, A.D. and Iyayi, E.A., pp: 98-100.

Obi, I.I., 2002. Statistical Methods of Detecting Differences Between Treatment Means and Research Methodology Issues: Laboratory and field Experiment, 2nd Edn. A.P Express publications Ltd. Nsukka Nigeria.

Okon, B.I., M.B. Obi and A.A. Ayuk, 2007. Performance of quails *(Coturnix coturnix Japonica)* fed graded levels of boiled sun dried taro cocoyam *(Colocasia esculenta)* as replacement for maize. Medwell Outline Agric. J., 2: 654 -657.

Olaboro, G., M.W. Mugerwa, J.S. and J.D. Latshav, 1991. Growth depressing factors in velvet beans fed to broiler chickens. East Afr. Agric. and Forestry J., 57: 103-110.

Ologhobo, A.D., D.F. Apata and A. Oyejide, 1993. Utilization of raw jackbean (*Canavalia ensiformis*) and jackbean fractions in diets of broiler chicks. Br. Poult. Sci., 34: 323-337.

Oluyemi, J.A. and F.A. Roberts, 2000. Poultry Production in Warm Wet Climates. 2nd Edn., Spetrum Books Limited, Ibadan.Nigeria.

Siddhuraju, P., K. Vijayajumari and K. Janardhanan, 1996. Chemical Composition and Protein quality of the little known legume, velvet bean *(Mucuna Pruriens)* (L) DC.). J. Agric. and Food Chem., 44: 2623-2641.

Smith, A.J., 2001. Poultry. The Tropical Agriculturalist. Revised ed Macmillan Education Ltd. London, pp: 1-11.

Tuleun, C.D. and J.P. Patrick, 2007. Effect of duration of cooking Mucuna utilis seed on pioximate composition, levels of antinutitional factors and performance of broiler chickens. Nig. J. Anim. Prod., 34: 45-53.

Tuleun, C.D., S.N Carew and I. Ijiji, 2008. Feeding value of velvet bean *(Mucuna utilis)* for laying hens. Livestock Res. Rural Development, 20: 152-159.

Udedibie, A.B.I. and C.R. Carlini, 1998. Brazilian *Mucuna pruriens* seeds (Velvet bean) lack haemoglutinating activity. J. Agric. and Food Chem., 46: 1450-1452.

Ukachukwu, S.N., F.C. Obioha and N. Amechi, 1999a. Toxicity of raw *Mucuna cochinchinesis* extract on broiler chicks. J. Sustainable Agric. and Environ., 1: 123-126.

Ukachukwu, S.N., F.C. Obioha and R.C. Madubuike, 1999b. Determination of the True Metabolizable Energy (TME) of raw and heat treated *Mucuna cochinchinesis* using adult broilers. Trop. J. Anim. Sci., 3: L25-31.

Ukachukwu, S.N., 2000. Chemical and nutritional evaluation of *Mucuna cochinchinesis* (Lyon's Bean) an alternative protein ingredient in broiler diets. Ph.D. Thesis, Univ. of Nsukka, Nigeria.