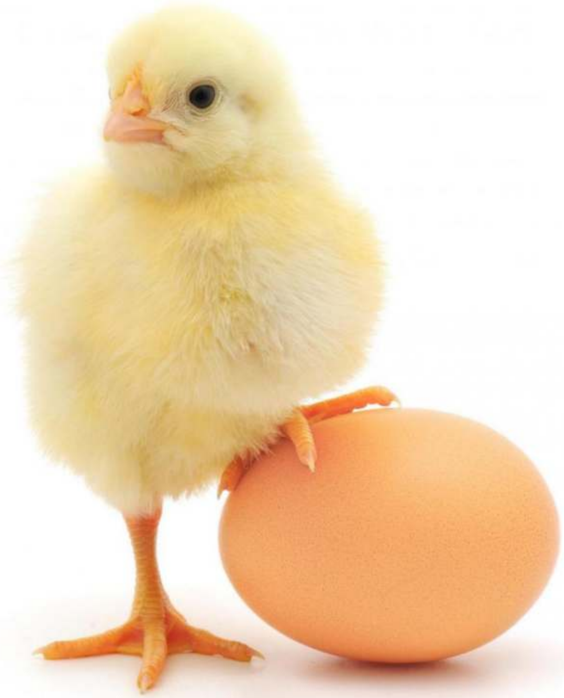
ISSN 1682-8356
ansinet.org/ijps



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 11 (1): 55-60, 2012
ISSN 1682-8356

The Potential of *Acacia angustissima* Leaf Meal as a Supplementary Feed Source in Broiler Finisher Diets

S. Ncube[1], H. Hamudikuwanda[1,2] and P. Banda[1]
[1]Department of Animal Science, Faculty of Agriculture, University of Zimbabwe,
Box 167, Mt. Pleasant, Harare, Zimbabwe
[2]ABSTCM UDCP, P.O. Box 35, Nyagatare, Rwanda

Abstract: This study evaluated, in a completely randomized design with five replicates, performance of Ross broiler chicks fed diets with 0 to 15% of *Acacia angustissima* leaf meal (leaf meal) from the fifth week to the end of the eight week of growth. Feed intake, weekly bodyweight, bodyweight gain, feed conversion ratio and carcass characteristics were determined. Feed intake, body weight gain and feed conversion ratio in birds on the 0% to 5% were not different ($p<0.05$). Broilers on 10% and 15% leaf meal had lower ($p<0.05$) bodyweight gain than those on the 0% and 5% leaf meal. However, birds on the 10% and 15% leaf consistently gained bodyweight and did not show any abnormalities or signs of disease. It is concluded that up to 15% leaf meal can be included in broiler finisher diets; however, 5% leaf meal appears to be the optimum inclusion rate for normal growth.

Key words: *Acacia angustissima*, leaf meal, finisher diet, broiler, growth

INTRODUCTION

Problems faced by poultry farmers include inadequate availability of feed and chicks, an inadequate supply of vaccines and high prices of feed (Sarker *et al.*, 1999). The high prices and unavailability of feeds and competition with humans has resulted in deficits of both protein and energy sources in most regions. For example, in Zimbabwe, while climatic conditions are suitable for production of the major ingredients in poultry feeds, maize and soyabeans, there is insufficient capacity to grow them. This feed deficit and the high feed costs have led to a search for alternative feed sources, particularly for smallholder and emerging large scale poultry farmers (Mutayoba *et al.*, 2011).

While the potential use of leguminous leaf meals in poultry diets has long been recognized, considerable research has concentrated on *Leucaena* species (Guodao and Dongjing, 1998; Hien and Hung, 1998) and other species including *Gliricida sepium* and *Sesbania sesban* (D'Mello, 1995). When fed at optimum rates, leaf meals supplement protein needs leading to higher body weight gain and reduced feed cost (D'Mello, 1995; Hien and Hung, 1998; Hien and Inh, 1998). Optimum leaf meal level in poultry diets ranges from 4 to 15% and varies with plant species (Guodao and Dongjing, 1998; Hien and Hung, 1998; Ige *et al.*, 2006). The variable optimum dietary leaf meal level precludes blanket inclusion level recommendations across plant species. Plant species differ in growth adaptability, herbage yield, susceptibility to pests and diseases, palatability, levels and types of toxins and anti-nutritive factors. For example, while *Leucaena* species leaf meals have been included in poultry diets, some species are susceptible to psyllid pest damage. In addition, *Leucaena* species forage contains mimosin, a toxin detrimental to animal health, particularly in non-ruminants (Hien and Inh, 1998).

A legume tree species that has been relatively recently been widely propagated in agroforestry is *Acacia angustissima* (Miller) Kuntze. It is is a member of the Mimosaceae family and is thought to have originated in Belize, Central America (Dzowela, 1994). It is a tropical legume recommended for use as a fodder tree due to its high potential growth rate and nitrogen fixing capabilities (Preece and Brook, 1999). It tolerates occasional freezing conditions, withstands periods of drought, grows rapidly and responds well to regular cutting (Dzowela, 1994). *Acacia angustissima* grows as a thornless shrub or small tree mostly 2-7 m high with a single short trunk., Biomass production can be up to 12.4 t DM ha^{-1} depending on tree spacing and cutting back height after each harvest (Preece and Brook, 1999). *Acacia angustissima* has been used as ruminant fodder but it contains toxic substances including tannins (polyphenols) that obviate ruminants from consuming large quantities (Odenyo *et al.*, 2003; Smith *et al.*, 2003). However, there is interest in feeding leaves of acacia trees to supplement protein needs of non-ruminant animals (Mashamaite *et al.*, 2009). Based on the known effects of *A. angustissima* in ruminants and other leaf meals, we hypothesize that *A. angustissima* can be included up to 15% in broiler diets for the relatively short finishing period without detrimental effects on growth and health.

Corresponding Author: S. Ncube, Department of Animal Science, Faculty of Agriculture, University of Zimbabwe, Box 167, Mt. Pleasant, Harare, Zimbabwe.
[2]Current address of H. Hamudikuwanda

Table 1: Chemical composition of *Acacia angustissima* leaf meal

Nutritional component	Percentage (%)
Dry matter (DM)	91.81
Ash	3.75
Crude protein (CP)	22.13
Ether extract (EE)	5.65
Crude fibre (CF)	9.86
Total tannins	2.44
Calcium (Ca)	1.20
Phosphorus (P)	0.43

Table 2: Control and *Acacia angustissima* diets ingredients (%) and chemical composition

	Acacia angustissima level (%)			
Ingredients	0 (Control)	5	10	15
Maize	60.80	57.50	55.00	53.00
Leaf meal	0.00	5.00	10.00	15.00
Soyabean	31.70	29.80	25.90	21.30
Sunflower cake	0.09	0.09	1.50	2.50
DL-methionine	0.13	0.17	0.17	0.26
Salt	0.25	0.25	0.25	0.25
Monocalcium phosphate	1.39	1.26	1.14	1.04
Oil	3.70	4.11	4.17	4.69
[1]Mineral and Vitamin	0.50	0.50	0.50	0.50
Lysine-HCL	0.00	0.00	0.10	0.25
Limestone	1.46	1.39	1.30	1.21
Total	100.00	100.00	100.00	100.00
Chemical composition				
% DM	88.70	88.70	89.20	89.10
% CP	18.99	18.58	18.73	19.03
ME (MJ/kg)	13.00	13.20	13.20	13.30
% Ca	0.17	0.15	0.13	0.18
% P	0.005	0.005	0.005	0.006
% CF	2.10	4.10	4.40	5.40
% Tannins	0.004	0.027	0.140	0.160

[1]Mineral and Vitamin Premix General ® from Hamish Cameron Pvt. Ltd, Harare, Zimbabwe

Consistent with this hypothesis, the main objective of this study was to determine the optimum inclusion rate of *Acacia angustissima* leaf meal in broiler finisher diets.

MATERIALS AND METHODS

Study site: The study was conducted at Henderson Research Station, Mazowe, Zimbabwe (17°35'S, 30°58'E). The predominant vegetation is tree savanna or bush clump savanna with tall perennial grasses such as *Hyparrhenia filipendula* on red clay soils. Associated woody species include various *Acacia* species and *Brachystegia spiciformis*. The station is located on the watershed of Zimbabwe at an altitude of 1200 m. Rainfall is confined to summer (November through to March) and is moderately high (750-1000 mm). The mean annual temperature ranges from 20-30°C.

Harvesting and preparation of *A. angustissima* leaf meal: The *A. angustissima* leaves were harvested from Domboshawa, 25 km northeast of Harare, at mid-maturity stage. Domboshawa is 31°13´E and 17° 30´S and has an altitude of 1530 m. Soils at the site are sandy-loam in texture and largely of granitic origin. Mean monthly summer temperatures rise up to a maximum of 28°C in October while mean monthly winter temperatures fall to a minimum of 5.5°C in July. The predominant natural vegetation is tree savanna with *Brachystegia* and *Hyparrhenia* species as the dominant tree and grass species, respectively. Leaves were harvested by cutting branches at least 1 m above the ground to allow for re-growth. After cutting, the leaves were pruned from the branches, air-dried in a shed to less than 13% moisture content. The dried leaves were then ground to pass through a 1mm sieve using a hammer mill. The ground *A. angustissima* leaf meal (leaf meal) was then incorporated in diets at 5, 10 and 15% of the total diet by weight (Table 1 and 2).

Experimental design and procedure: Three hundred four-week old unsexed Ross broiler chicks with a mean bodyweight of 785.6±3.21 g were randomly allocated to 20 groups (15 birds/group). The groups were then randomly allocated to four iso-nitrogenous and iso-energetic broiler finisher diets (0 - control, 5, 10 and 15% leaf meal; Table 2) giving 5 replicates/treatment in a Completely Randomized Experimental Design (CRD).
The broilers in each group (replicate) were housed in one pen and fed *ad libitum* for four weeks. Water was always available during the experimental period. The birds were checked daily for any signs of disease or abnormal behavior. At the end of the four-week experimental period, 10 birds from each treatment (2 per replicate) were randomly selected and slaughtered. The liver, heart, gizzards and intestines were inspected by a veterinarian for clinical abnormalities. Organ weights and measurements were taken and compared to those of birds from the control diet.

Measurements and statistical analysis: Weekly replicate (group) bodyweights and feed intake were recorded in order to calculate bodyweight gain and Feed Conversion Ratio (FCR). During slaughter, individual body weights and hot dressed mass per bird were measured.
The effect of dietary treatments on feed intake, bodyweights and bodyweight gain, was determined by repeated measures ANOVA using the PROC MIXED procedure of SAS (1998). Apart from treatments, the models included the explanatory variables, week (time) of experiment and interaction of time and treatment. Pairs of means were compared using the Predicted Difference (PDiff) statistic of SAS.
In order to derive predictive relationship of *A. angustissima* levels with feed intake or bodyweight, linear and quadratic regression analysis in which treatment levels were regressed on the latter response variables were conducted. Initial bird bodyweight was included as a covariate in the regression models.

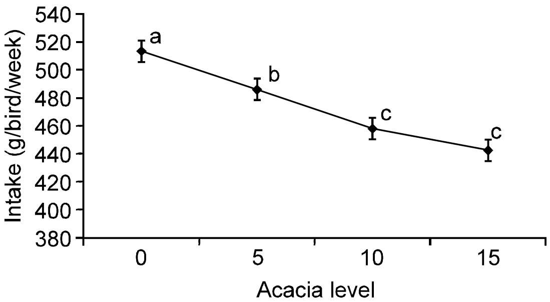


Fig. 1: Feed intake (LS mean) of broilers on four diets with increasing levels (0, 5, 10 and 15%) of *Acacia angustissima* leaf meal over the four-week experimental period. [abc]Means across Acacia levels with different letters differ ($p<0.05$)

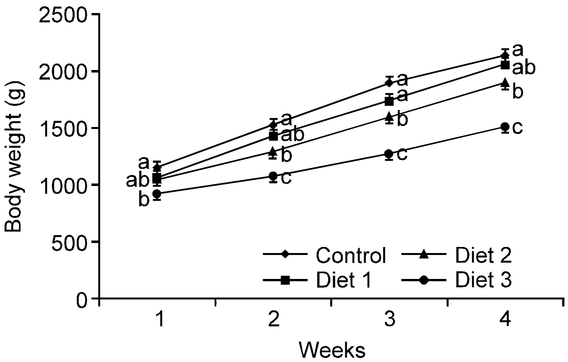


Fig. 2: Weekly bodyweights (g) of birds on different Acacia treatments. [abc]At each week, means with different letters differ ($p<0.05$)

RESULTS

Feed intake: Feed intake linearly decreased ($p<0.05$) with increasing leaf meal levels (Fig. 1). The regression equation for feed intake regressed on leaf meal level was, Feed intake = 510.6 (±3.75) - 4.8 (±0.40) X, where X is the level of leaf meal. The R^2 value of the model was 97 %. Feed intake for birds on the control diet was higher ($p<0.05$) than for leaf meal-based diets (Fig. 1). Among the leaf meal diets, feed intake of birds was higher ($p<0.05$) for the 5% leaf meal than for the 10% and 15% leaf meal diets.

Weekly bodyweights: There was an interaction ($p<0.05$) between diet and week of experiment (time) on bird bodyweights (Fig. 2). Bodyweights for birds on 15% leaf meal were lower ($p<0.05$) from Week 1 than for the control. At Week 2, birds from the control had higher ($p<0.05$) bodyweights than birds on the 10% and 15% leaf meal diets. Also, birds on the 5% and 10% leaf meals had higher ($p<0.05$) bodyweights than those on 15% leaf meal. The birds on 15% leaf meal consistently had lower ($p<0.05$) bodyweights than the control and the

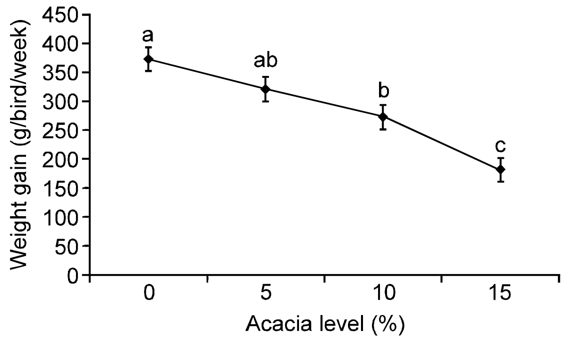


Fig. 3: Mean body weight gain of broilers on Acacia treatments over the experimental period. [abc]Mean bodyweight gains across *A. angustissima* levels with different letters differ ($p<0.05$)

other leaf meal treatments from Week 2 up to the end of the experiment (Week 4). At Week 3, bodyweights for birds on the control and 5% leaf meal diets were higher ($p<0.05$) than for birds on the 10% leaf meal diet. However, at Week 4 only birds on the control diet had higher ($p<0.05$) bodyweight than those on 10% leaf meal. Bodyweights for birds on the control and 5% leaf meal were not different ($p>0.05$) for the whole trial period (Fig. 2).

Weekly bodyweight gain: Initial body weight and time (week of experiment) had no effect ($p>0.05$) on weekly weight gain. The control and 5% and 10% leaf meal birds had a higher ($p<0.05$) mean weekly bodyweight gain than birds on the 15% leaf meal diet for at least the last 3 wk of the experiment (Fig. 3). Birds on the control diet had higher ($p<0.05$) mean weekly bodyweight gain than birds on the 10% leaf meal diet for the last 3 weeks of the experiment. Bodyweight was higher ($p<0.05$) in birds on the 5% than those on the 10% leaf meal only during the third week of the experiment. In general, weekly bodyweight gain linearly decreased ($p<0.05$) with increasing levels of leaf meal (Fig. 3). The regression equation for mean weekly bodyweight gain regressed on leaf meal level was, bodyweight gain = 380.8 (±13.43) - 12.5 (±1.44) X where X is the level of leaf meal. The R^2 value for the model was 96%. However, bodyweight gain for birds on 5% leaf meal was not different ($p<0.05$) from that of birds in the control group.

Food conversion ratio: Initial bodyweight of birds and time did not affect ($p>0.05$) FCR. There was no interaction ($p>0.05$) between diet and time on FCR. However, FCR for birds on the control 5% and 10% leaf meal were lower ($p<0.05$) than that for birds on the 15% leaf meal diet (Fig. 4).

Diseases, abnormalities and carcass characteristics: There were no treatment related diseases or

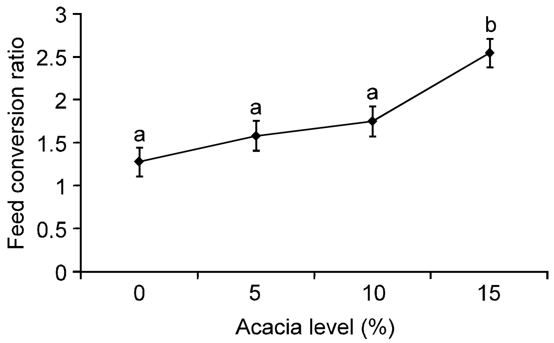


Fig .4: Feed coversion ratios of broilers on different Acacia treatments over the experimental period. [ab]Mean FCRs accross *A. angustissima* levels with different letters differ ($p<0.05$).

abnormalities on birds across the control and leaf meal diets. There were no clinical abnormalities on the broiler carcasses or internal organs. The skins of birds on the leaf meal diets were yellow in colour.

DISCUSSION

The decrease in feed intake with increasing leaf meal level was partly caused by commensurate increases in fibre and tannin contents. High dietary fibre content restricts feed intake due to increased bulk density. Increased crude fibre content increases feed volume (Gous *et al*., 1990) and this limits feed intake by birds. Tannin increase may also have increased unpalatability of the feed and consequently reduced feed intake. However, these results are contrary to those of D'Mello *et al*. (1987) who concluded that feed intake in chicks on a 10% *Leucaena leucocephala* diet was not significantly affected. This could be a result of disparate leaf meal quality; for example, *L. leucocephala* is more digestible and palatable than *A. angustissima* leaf (Maasdorp, 2004). In a study by Mashamaite *et al*. (2009), feed intake was not different between rabbits fed a concentrate-based control diet and those supplemented with tanniniferous browses of *Acacia karroo*, *Acacia nilotica* and *Acacia tortilis*. According to Al Mamary *et al*. (2001), a low tannin diet should not reduce feed intake of monogastric animals although higher levels of tannins have a negative effect on growth. However, the effect of tannins depends on the type and level of tannins and the dietary nutrients involved (McNabb *et al*., 1998). These effects and the lack of consistent and agreed standard methods to measure tannin content leads to difficulty in comparing results from different studies. However, in this study, decrease in feed intake with increase in leaf meal content could still have been caused by tannins.

The lower bodyweight for birds on 15% leaf meal than for the control and other leaf meal treatments, virtually throughout the experimental period, could have been caused by lower energy intake. This lower energy intake was likely a consequence of the higher fibre intake which reduces energy density. Also, the higher fibre content could have reduced nutrient release. According to D'Mello (1995), relatively high fibre content limits leaf meal use in non-ruminant diets. Results from this study are consistent with those of D'Mello (1992) in which chicks fed graded levels of *L. leucocephala* leaf meal had a dose-dependent growth depression. Iyayi and Fayoyi (2005) also reported a reduction in weight gain with increasing levels of dietary fibre. Working with rabbits, Raharjo *et al*. (1986) concluded that despite the favourable digestibility of the crude protein fraction of *L. leucocephala* leaf meal for rabbits, graded levels of this legume also caused growth depressions. Also, the broilers could have been fed for an inadequate duration to adapt to the leaf meal diets. It is conjectured that the birds would have comparable performance to the control birds if they had been fed for more than 4 wk.

Even though bird feed intake for the control diet was higher than for the 5% leaf meal, the similar bodyweight gains cannot be explained by their FCRs, which were similar. This suggests that the nutritive qualities of these two diets were similar. The 5% leaf meal was therefore as good as the soyabean meal-based control diet on body weight gain across the experimental period. However, Mutayoba *et al*. (2011) after a comprehensive analysis of cereals, oilseed meals and leaf meals, reported soyabean meal to be the best source of most amino acids. Leaf meals including that of Leucaena had, in general, high mineral and high amino acid (e.g., lysine) content, although not as high as for soyabean meal. Leaf meal could probably be included at more than 5% level for relatively poor poultry protein sources which are on the market today (e.g. cottonseed cake and sunflower cake).

The lower body weight gain of birds on 15% leaf meal corresponds to the higher FCR and lower feed intake of the broilers in this group than those on the other treatments and control. However, while weekly bodyweight and bodyweight gain were lower for the 15% leaf meal birds than the rest of the groups, for at least the last 3 weeks of the experiment, the continued gain in bodyweight throughout the experimental period indicates that this diet can still be a feeding option. In addition, the birds neither showed signs of disease nor were abnormalities detected in the internal organs. These results indicate that birds can be fed 15% leaf meal with little consequence except reduced growth rate.

Similarly, while the weekly bodyweights of the birds on 10% leaf meal were lower for the last 3 weeks of the experiment, the birds continued gaining weight and had no abnormalities and were free of disease indicating that broilers could be fed 10% leaf meal finisher without consequence except lower bodyweight gain than control diets. Given this evidence, our hypothesis that leaf meal can be fed up to 15% without compromising growth is not accepted. However, leaf meal can be fed up to 15% and can sustain acceptable growth rates without detriment to bird health. Consistent with this finding Ige *et al*. (2006) found that 15% *Gliricidia sepium* leaf meal could be included in layer diets without adverse effect. However, other workers (Guodao and Dongjing, 1998; Hien and Hung, 1998) found the optimum *Leucaena* leaf meal inclusion rate in broiler diets to be 4%. This is close to the optimum inclusion rate of 5% obtained in this study. The presence of toxins sich as mimosin in *Leucaena* species and tannins in *A. angustissima* would limit inclusion rate. It is surprising that *A. angustissima* leaf meal would have little deleterious effects in broilers and yet in ruminants that normally handle toxins better several reports have shown detrimental effects that were, however, ameliorated by adding polyethylene glycol (Odenyo *et al*., 2003).

Conclusion: *Acacia angustissima* leaf meal can be included in broiler finisher diets up to 15% without causing any deleterious effects. However, the appropriate inclusion rate in finisher diets, based on optimum growth rate and FCR was 5%. Future studies need to test feeding of *A. angustissima* for a longer period and for the broiler starter and finisher rearing phases.

ACKNOWLEDGEMENTS

We thank ANAFE, International Center for Research in Agroforestry (ICRAF) and Regional Universities forum for Agricultural Research (RUFORUM) for the financial support through scholarships to S. Ncube. We also thank the Department of Animal Science technical staff and Henderson Research Station Poultry Unit staff for the support given throughout the project.

REFERENCES

Al Mamary, M., A. Molham, A. Abdulwali and A. Al-Obeide, 2001. *In vivo* effect of dietary sorghum tannins on rabbit digestive enzyme and mineral absorption. Nutr. Res., 21: 1393-1401.

D'Mello, J.P.F., T. Akamovic and A.G. Walker, 1987. Evaluation of Leucaena leaf meal for broiler growth and pigmentation. Trop. Agric. (Trinidad), 64: 33-35.

D'Mello, J.P.F., 1995. Leguminous leaf meal in non-ruminant nutrition. In: Tropical Legumes in Animal Nutrition, D'Mello, J.P.F. and C. Devendra (Eds), London, CAB. International.

D'Mello, J.P.F., 1992. Chemical constraints to the use of tropical legumes in animal nutrition. Anim. Feed Sci. Technol., 38: 237-261.

Dzowela, B.H., 1994. *Acacia angustissima* a Central American tree that's going places. Agroforestry Today, 6: 13-14.

Guodao, L. and W. Dongjing, 1998. Preliminary study of *Leucaena leucocephala* as feed for livestock. In: *Leucaena* Adaptation Quality and Farming Systems, Shelton, H.M., R.C. Gutteridge, B.F. Mullen and R.A. Bray (Eds). Proceedings of a workshop held in Hanoi, Vietnam 9-14 February 1998. Australian Centre for International Agricultural Research, pp: 284-285. Accessed from http://aciar.gov.au/files/node/331/PR0086%20part%2015.pdf [Accessed 30 August 2011].

Gous, R.M., G.C. Emmans, L.A. Broadbent and C. Fisher, 1990. Nutritional effects on the growth and fatness of broilers. Br. Poult. Sci., 31: 495-505.

Hien, T.Q. and N.D. Hung, 1998. The effect of *Leucaena* leaf meal on egg quality and growth of broiler chickens. In: *Leucaena* Adaptation Quality and Farming Systems, Shelton, H.M., R.C. Gutteridge, B.F. Mullen and R.A. Bray (Eds). Proceedings of a workshop held in Hanoi, Vietnam 9-14 February 1998. Australian Centre for International Agricultural Research, pp: 296-297. Accessed from http://aciar.gov.au/files/node/331/PR0086%20part%2015.pdf [Accessed 30 August 2011].

Hien, T.Q. and N.T. Inh, 1998. The effect of supplementing the diet of broiler chickens with *Leucaena* leaf meal and $FeSO_4$. In: *Leucaena* Adaptation Quality and Farming Systems, Shelton, H.M., R.C. Gutteridge, B.F. Mullen and R.A. Bray (Eds). Proceedings of a workshop held in Hanoi, Vietnam 9-14 February 1998. Australian Centre for International Agricultural Research, pp: 298-299. Accessed from http://aciar.gov.au/files/node/331/PR0086%20part%2015.pdf [Accessed 30 August 2011].

Ige, A.O., A.A. Odunsi, J.A. Akinlade, L.O. Ojedapo, S.A. Ameen, O.A. Aderinola and T.A. Rafiu, 2006. Gliricidia leaf meal in layer's diet: Effect on performance, nutrient digestibility and economy of production. J. Anim. Vet. Adv., 5: 483-486.

Iyayi, E.A. and F.K. Fayoyi, 2005. Effects of feeding cassava fruit coat meal on the nutrient digestibility and performance of broilers. Livest. Res. for Rural Dev., 17(13) Retrieved May 5. 2006 from http://www/cipav.org.co/lrrd/lrrd17/01/17013. htm.

Mashamaite, L., J.W. Ng'ambi, D. Norris, L.R. Ndlovu and C.A. Mbajiorgu, 2009. Relationship between tannin contents and short-term biological responses in male rabbits supplemented with leaves of different acacia tree species grown in Limpopo province of South Africa. Livestock Research for Rural Development, 21: Article #109. Accessed from http://www.lrrd.org/lrrd21/7/mash21109.htm [Accessed 25 March 2011].

Maasdorp, B., 2004. Which trees? In: L. Hove (Ed) Growing trees for profitable milk production. A manual for farmers and extension staff. World Agroforestry Center (ICRAF). Harare, Zimbabwe.

McNabb, W.C., J. Peters, L.Y.S. Foo, G.C. Waghorn and F.S. Jackson, 1998. Effect of condensed tannins prepared from several forages on the *in vitro* precipitation of ribulose 1.5 biosphophate caboxylase (rubisco) protein and its digestion by trypsin (EC 2.4.21.4) and chymotrypsin (EC2.4.21.1). J. Sci. Agric., 77: 201-212.

Mutayoba, S.K., E. Dierenfeld, V.A. Mercedes, Y. Frances and C.D. Knight, 2011. Determination of chemical composition and anti-nutritive components for Tanzanian locally available poultry feed ingredients. Int. J. Poult. Sci., 10: 350-357.

Odenyo, A.A., P.O. Osuji, J.D. Reed, A.H. Smith, R.I. Mackie, C.S. McSweeney and J. Hanson, 2003. *Acacia angustissima*: Its anti-nutrients constituents, toxicity and possible mechanisms to alleviate the toxicity - a short review. Agroforestry Syst., 59: 141-147.

Preece, D. and R. Brook, 1999. *Acacia angustissima* - a promising species for agroforestry? In: FACT Sheet 99-01, January 1999, A Quick Guide to Multipurpose Trees from Around the World. FACT Net, Winrock International, Arkansas. Accessed from http://www.winrock.org/forestry/factpub/FACTSH/www.winrock.org/forestry/factnet.html [Accessed 30 August 20110].

Raharjo, Y.C., P.R. Cheeke, O.N.N.M. Patt and K. Supriyati, 1986. Evaluation of tropical forages and by-product feeds for rabbit production. I. Nutrient digestibility and effect of heat treatment. J. Applied Rabbit Res., 9: 56-66.

Sarker, S.C., J. Abedin and S.M.F. Islam, 1999. The performance of commercial poultry farms: A profitability and efficiency analysis. Bangladesh J. Agric. Econ., 22: 63-75.

SAS, 1998. Propriety software release 8.1. Statistical analysis Systems Institute, INC., Cary, North Carolina, USA.

Smith, A.H., M.A. Wallig, D.S. Seiglerd, A.A. Odenyo, C.S. McSweeney and R.I. Mackie, 2003. Ameliorating toxic effects of *Acacia angustissima* with polyethylene glycol in rats. Anim. Feed Sci. Technol., 106: 165-174.