ISSN 1996-3351

Asian Journal of Biological Sciences

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OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2019.180.186

Research Article
Dietary Inclusion of Neem (*Azadirachta indica*) Leaf Meal Can Influence Growth Performance and Carcass Characteristics of Broiler Chickens

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Abstract

Background and Objective: Synthetic and semi-synthetic antibiotics as growth promoters are widely used in poultry production with some positive and negative effects and this has redirected research to natural antimicrobial products and plant leaves like neem leaf meal. The relevance of neem leaf meal as a growth promoter is due to its useful medicinal properties such as antibacterial, antiviral, antifungal, antiprotozoal, hepatoprotective, immunomodulatory and other peculiarities. This study therefore evaluated the effect of dietary inclusion of neem leaf meal (NLM) on the growth performance and carcass characteristics of broiler chickens. **Materials and Methods:** The feeding trial lasted for 8 weeks and a total of 192 day-old broiler chicks were used. The chicks were randomly allotted to four dietary treatments of 48 birds per treatment and replicated thrice with 16 birds per replicate in a completely randomized design (CRD). Four iso-caloric and iso-nitrogenous diets were formulated containing NLM at inclusion levels 0, 2.5, 5 and 7.5% for T_1, T_2, T_3 and T_4, respectively. Appropriate data on growth performance and carcass characteristics were determined and results subjected to one-way ANOVA accordingly. **Results:** Results showed the proximate composition of the NLM as 94 DM, 22.4 CP, 20.5 CF, 3 EE, 12.2 ash and 41.9% NFE. At the starter phase, performance traits like the average final weight, total weight gain, daily weight gain and feed conversion ratio were not significantly ($p>0.05$) affected by dietary treatments, with the exception of the average daily feed intake was significantly ($p<0.05$) different. All the parameters reduced in value across dietary treatments as the inclusion levels of NLM increased. At the finisher phase, the average total weight gain, daily weight gain, daily feed intake and FCR were significantly ($p<0.05$) influenced by dietary treatments. Generally, birds fed NLM beyond 2.5% inclusion level recorded poorer growth performance characteristics compared with the lower level (2.5%) and control diet. Results for carcass characteristics, cut-up parts and internal organs of broiler chickens fed NLM showed no significant ($p>0.05$) differences between treatments, implying that NLM might not adverse effect on the carcass characteristics. **Conclusion:** The study concluded that 2.5% NLM can be included in diets meant for broiler chickens without fear of compromising growth performance and carcass characteristics.

Key words: Neem leaf meal, growth performance, carcass characteristics, broiler chickens

Received: November 26, 2018 Accepted: January 01, 2019 Published: March 15, 2019

Citation: J.A. Ubua, P.O. Ozung and P.G. Inagu, 2019. Dietary inclusion of neem (*Azadirachta indica*) leaf meal can influence growth performance and carcass characteristics of broiler chickens. Asian J. Biol. Sci., 12: 180-186.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The importance of poultry production to the socio-economic development of any country cannot be overemphasized as a result of its ability to provide animal protein at a relatively shorter duration as compared to other animals. Nevertheless, in most developing countries, the rate of population growth surpasses the growth in the poultry industry and therefore raises food security concerns as poultry products are less available to the populace[1]. As a result of this, concerted effort is required to discover ways and means to increase animal production to bridge the deficit in animal protein intake[2]. This could be achieved by engaging in cost effective ways of producing animals especially poultry that could play a role in bridging the protein gap.

There are so many sources of protein for human consumption and in view of the high demand for protein; broiler production can serve as an alternative potential source to meet this demand. This is because the duration of broiler production is quite short and within 6-8 weeks, the birds are ready for the market and human consumption[3]. It also brings a faster return to farmers. In recent times, broiler meat has become popular in Nigeria without any religious restrictions. Also, poultry is one of the most efficient and economic converters of vegetable food into animal protein and provides a quick and rapid outcome as compared to production of animals.

Feed alone has been reported to account for 60-80% of total cost of livestock production in developing countries[4]. Hence, the major constraint to poultry production is the high cost of conventional feeding stuffs especially the primary energy and protein sources. In view of this, poultry farmers are searching for non-conventional feed ingredients that may be cheaper, such as leaf meals of ethno-medicinal plants[5,6]. Leaf meals have been incorporated in the diets of poultry as a means of reducing the high cost of conventional protein sources[1]. Another way to reduce costs is to incorporate feed additives or growth promoters which boost animal performance by increasing growth rate, better feed conversion efficiency, greater livability and lowered mortality in poultry[7].

Synthetic and semi-synthetic antibiotics as growth promoters are widely used in poultry production. Their use has generated some positive and negative effects over the years and this has redirected research to natural antimicrobial products. Kibria and Verna[8] reported that consumption of meat from broilers that were fed antibiotic growth promoters resulted in antibiotic residues entering the human body and thereby causing serious health hazards in humans. As a result of the negative outcome of antibiotics, there is considerable research interest in the possible use of natural products, such as essential oils, extracts of edible and medicinal plants, herbs and spices, for the development of new additives in animal feeding[2].

Craig[9] stated that many herbs could help provide some protection against bacteria and stimulate the immune system and hence the overall growth and well being of birds. Neem Leaf Meal (NLM) can be incorporated in small quantities that serve as natural growth promoters through its antimicrobial activity. The relevance of neem leaf meal as a growth promoter is due to the fact that it is known for its useful medicinal properties such as antibacterial, antiviral, antifungal, antiprotozoal, hepatoprotective, immunomodulatory and other properties without showing adverse effects on birds[10,11]. Neem promotes growth because of its antibacterial and hepatoprotective properties[12]. Neem leaf meal has a proximate composition of 92.40% dry matter, 20.68% crude protein, 16.60% crude fibre, 4.13% ether extract, 7.10% ash and 43.91% Nitrogen free extract[4]. However, neem leaf meal has anti-nutritional factors which may affect nutrients utilization hence its usage is drastically reduced in feeds to capture its beneficial effects with less adverse effects. This study was therefore; designed to investigate the growth performance and carcass characteristics of broiler chickens fed dietary inclusion levels of neem leaf meal (NLM) in a humid rainforest zone of Nigeria.

MATERIALS AND METHODS

Location of the study: The study was conducted at the Poultry Unit of the Teaching and Research Farm, Taraba State University, Jalingo, Ardo-Kola Local Government Area, Taraba State, Nigeria. It is located within the Guinea Savanna Zone. It lies between latitude 8°50' North and longitude 11°31' East of the equator. The state was characterized by tropical climate marked by dry and rainy seasons. The rainy season usually commences in the month of March and ends up in October. The dry season then started in late October and ends in March. The annual rainfall was between 1000 and 1500 mm with an average minimum temperature of 30°C and maximum temperature of 38°C depending on the season[13].

Source and processing of neem leaf meal (NLM): Fresh neem leaves were harvested from neem trees within the premises of the university. The harvested leaves were air-dried for 7-8 days until they become crispy retaining their greenish colouration.

The dried neem leaves were later milled using a hammer mill to 1 mm sieve size to enable birds pick feed easily while feeding.

Experimental birds, design and management: One hundred and ninety two unsexed day-old broiler chicks (Arbor acres) strain were purchased from a reputable hatchery in Ibadan, Oyo State-Nigeria. The birds were randomly allotted to four dietary treatments with 48 birds per treatment where each treatment was further replicated 3 times with 16 birds per replicate in a Completely Randomized Design (CRD). The birds were raised on deep litter system in two phases; Starter (0-4 weeks) and finisher (5-8 weeks) phase. Routine vaccination schedules were strictly adhered to and other management practices that ensure good health. Feed and water were supplied *ad libitum*.

Experimental diets: Four experimental diets were formulated with Neem Leaf Meal (NLM) incorporated at levels of 0 (control), 2.5, 5 and 7.5% designated as T_1, T_2, T_3 and T_4, respectively. The experimental diets were fed to the birds for 8 weeks (56 days) comprising the starter (23% CP) and finisher (20% CP) phases of production 4 weeks each 28 days. The compositions of starter and finisher diets for all treatments were shown in Table 1 and 2, respectively.

Proximate analysis of neem leaf meal and experimental diets: The proximate determination of neem leaf meal and experimental diets (starter and finisher) was carried-out at the Department of Fisheries Laboratory Unit, Modibbo Adama University of Technology Yola, Adamawa State, Nigeria to determine the dry matter, crude protein, crude fibre, ether extract, total ash and Nitrogen free extract using the procedures according to AOAC[14].

Table 1: Composition of broiler starter diets (0-4 weeks)

Ingredients	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)
Maize	42.64	41.64	40.64	39.64
Maize bran	10.00	10.00	10.00	10.00
Soybean (Full fat)	39.16	36.66	34.16	31.66
NLM	0.00	2.50	5.00	7.50
Fish meal	4.00	5.00	6.00	7.00
Limestone	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated analysis				
Crude protein (%)	23.00	23.00	23.02	23.03
ME (Kcal kg^{-1})	3,011.94	2,961.00	2,939.12	2,916.92
Crude fibre (%)	4.45	4.61	4.80	4.92

Table 2: Composition of broiler finisher diets (5-8 weeks)

Ingredients	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)
Maize	52.33	51.33	50.33	49.00
Maize bran	10.00	10.00	10.00	10.00
Soybean (full fat)	29.47	26.97	24.47	21.97
NLM	0.00	2.50	5.00	7.50
Fish meal	4.00	5.00	6.00	7.00
Limestone	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated analysis				
Crude protein (%)	20.00	20.01	20.02	20.03
ME (Kcal kg^{-1})	2,996.99	2,989.99	2,967.99	2,945.99
Crude fibre (%)	5.13	5.22	5.31	5.41

Premix: Vit. A:10,000,000 IU, Vit. D3: 2,000,000 IU, Vit. C: 20,000 mg, Vit. K: 2,000 mg, Vit. B1 = 3,000 mg, Vit. B2: 5,000 mg, Vit. B6: 45,000 mg, Vit. B12: 10,000 mg, Niacin: 4,000 mg, Pantothenic acid: 20 mg, Folic acid = 300,000 mg, Biotin: 1,000 mg, Choline chloride: 50 mg, Manganese: 300,000 mg, Zinc: 120,000 mg, Iron: 80,000 mg, Copper: 3,500 mg, Iodine: 1,500 mg, Selenium: 300 mg, Cobalt: 120 mg, Antioxidant: 120,000 mg, NLM: Neem leaf meal, ME: Metabolizable energy

Data collection

Feed intake: Feed intake was determined on daily basis as the difference between the quantity of feed fed the previous day and quantity left over the next morning.

Body weight: Initial body weight of the birds was taken at the start of the trial using electronic measuring scale and live weight measurements were carried out on weekly basis.

Feed conversion ratio (FCR): The feed conversion ratio was calculated as the ratio of feed intake over body weight gain.

Carcass characteristics: Carcass evaluation was done at the end (8th week) of feeding trial; 3 birds per treatment were randomly selected and fasted for 24 h for subsequent slaughtering and carcass evaluation. Each bird was weighed, slaughtered and bled. The birds were dipped in hot water to facilitate defeathering. The dressed weight of each bird was determined after the internal organs and shanks were removed, thereafter the primal cuts were carefully removed and weighed accordingly.

Statistical analysis: All data collected were subjected to one-way analysis of variance (ANOVA) using statistical package for

social sciences (SPSS) while significant means were separated using Duncan's Multiple Range Test (DMRT)[15].

RESULTS AND DISCUSSION

Proximate composition of neem leaf meal: The result for the proximate composition of the test ingredient (Neem) (*Azadirachta indica*) leaf meal was presented in Table 3. It showed 94% dry matter (DM), 22.4% crude protein (CP), 20.5% crude fibre (CF), 3% ether extract (EE), 12.2% ash and 41.9% Nitrogen free extracts (NFE). The result revealed that the CP content was within the range (18.90-24.06%) reported by other researchers[16-18]. The ash content was slightly at variance with the values reported by Esonu *et al.*[4] and Onyimonyi *et al.*[18] as 7.10 and 6.00%, respectively. These slight differences could be attributed to the variety of neem tree, the age of the leaves, the environment, soil type and also the method of processing the neem leaves.

Proximate composition of broiler starter diets (0-4 weeks): The proximate composition of the experimental diets for the starter phase was presented in Table 4. The dry matter (DM) of the broiler starter diets ranged from 92.50-94.00% across the treatments. The crude protein range (22.90-24.10%) was within the recommended value of 24% for broiler starter chickens[19,20]. The crude fibre (CF) ranged between 8.50 and 10.50% with highest level recorded in T_2 (2.5% inclusion). Ether extract was ranged between 9.50 and 13.50% across dietary treatments while ash content was between 8.00 and 10.10%. The Nitrogen free extract (NFE) ranged between 43.80 and 47.90% across the treatments with the lowest and highest levels recorded in T_3 and T_1, respectively. However, the energy range (3,020.95-3,142.65 Kcal kg^{-1} ME) across the treatments was similar to the energy requirement of 3,000 kcal kg^{-1} ME recommended for broiler starter chickens[19]. This implied that the diets were nutritionally adequate for the birds at the starter phase.

Table 3: Proximate composition of neem leaf meal (NLM)

Parameters	Composition (%)
Dry matter (DM)	94.00
Crude protein (CP)	22.40
Crude fibre (CF)	20.50
Ether extract (EE)	3.00
Ash	12.20
Nitrogen free extract (NFE)	41.90

Each mean value was obtained from triplicate proximate determinations

Table 4: Proximate composition of broiler starter diets

Parameters (%)	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Dry matter	94.00	92.50	93.50	94.00
Crude protein	24.10	23.50	22.90	23.00
Crude fibre	8.50	10.50	9.00	10.00
Ether extract	13.50	9.50	13.00	12.00
Ash	10.10	8.60	8.00	10.10
Nitrogen free extract (NFE)	43.80	47.90	47.10	44.90
*ME (Kcal kg^{-1})	3,142.65	3,024.00	3,055.58	3,020.95

Each mean value was obtained from triplicate proximate determinations, T_1: Treatment 1 (Control-without Neem Leaf Meal), T_2: Treatment 2 (2.5% neem leaf meal inclusion), T_3: Treatment 3 (5% Neem leaf meal inclusion), T_4: Treatment 4 (7.5% Neem leaf meal inclusion)

Proximate composition of broiler finisher diets (5-8 weeks): The proximate composition of the experimental diets at the finisher phase was presented in Table 5. The dry matter (DM) content across the dietary treatments was between 93 and 95%. The crude protein content (19.90-20.90%) was within the recommended value of 20% for broiler finishers[19]. The crude fibre (CF) ranged from 7.50-13.00%. Ether extract ranged 9.50 and 13.00% across the treatments while ash showed 8.60-12.00%. The Nitrogen free extracts (NFE) showed a range of 45.00-50.60% across the treatments. The energy level across the treatments was between 2,874.10 and 2,990.08 Kcal kg^{-1} ME. The energy levels were similar to the range of energy requirements recommended for broiler finishers[21].

Growth performance characteristics: The growth performance characteristics of broiler chickens fed dietary inclusion levels of Neem Leaf Meal (NLM) were presented in Table 6. The results showed no significant ($p>0.05$) differences between dietary treatments at the starter phase with the exception of average daily feed intake. Values recorded for mean final weight gain ranged from 446.67-519.67 g/bird, total weight gain ranged 408.67-478.67 g/bird, average daily weight gain ranged from 14.67-17.33 g/bird and mean daily feed intake was 23.03-25.87 g/bird. Birds fed diets containing 7.5% neem leaf meal recorded least values for final weight (446.67 g/bird), total weight gain (408.67 g/bird), average daily weight gain (14.67 g/bird) and average daily feed intake (23.03 g/bird). All these values decreased with increasing

Table 5: Proximate composition broiler finisher diets

Parameters (%)	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Dry matter	93.00	94.50	95.00	93.50
Crude protein	20.90	20.60	19.90	20.20
Crude fibre	13.00	10.50	11.50	7.50
Ether extract	12.50	9.50	13.00	10.50
Ash	8.60	12.00	8.90	11.20
Nitrogen free extracts (NFE)	45.00	47.40	46.70	50.60
*ME (Kcal kg^{-1})	2,933.50	2,874.10	2,878.55	2,990.08

Each mean value was obtained from triplicate proximate determinations, *ME: Metabolizable Energy, calculated from Pauzenga[22], T_1: Treatment 1 (Control-without Neem Leaf Meal), T_2: Treatment 2 (2.5% Neem Leaf Meal Inclusion), T_3: Treatment 3 (5% Neem leaf meal inclusion), T_4: Treatment 4 (7.5% Neem leaf meal inclusion)

Table 6: Performance of broiler chickens fed dietary levels of neem leaf meal

Parameters	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)	SEM
Starter					
Av. initial weight (g/bird)	38.00	39.33	37.67	38.00	0.47
Av. final weight (g/bird)	516.67	486.67	473.33	446.67	15.90
Av. total weight gain (g/bird)	478.67	447.00	435.67	408.67	15.64
ADWG (g/bird)	17.33	16.00	15.33	14.67	0.65
ADFI (g/bird)	25.87^{a}	25.13^{b}	24.30^{c}	23.03^{d}	0.14
Feed conversion ratio (FCR)	1.49	1.57	1.58	1.57	2.38
Mortality (%)	6.00	2.50	4.16	2.08	1.61
Finisher					
Av. initial weight (g/bird)	516.67	486.67	473.33	446.33	15.90
Av. final weight (g/bird)	1177.67	1244.67	979.00	897.00	43.68
Av. total weight gain (g/bird)	658.33^{ab}	769.67^{a}	505.67^{bc}	450.33^{c}	55.92
ADWG (g/bird)	23.67^{ab}	27.33^{a}	18.00^{bc}	16.00^{c}	2.08
ADFI (g/bird)	83.30^{a}	80.93^{ab}	79.00^{ab}	75.27^{b}	1.68
Feed conversion ratio (FCR)	3.52^{bc}	2.96^{c}	4.38^{ab}	4.70^{a}	0.08
Mortality (%)	2.50	1.50	1.33	1.20	0.12

T_1: Treatment 1 (Control-without neem leaf meal), T_2: Treatment 2 (2.5% neem leaf meal inclusion), T_3: Treatment 3 (5% neem leaf meal inclusion), T_4: Treatment 4 (7.5% neem leaf meal inclusion), Means within the same row bearing different superscripts differ significantly ($p<0.05$), SEM: Standard error of means, ADWG: Average daily weight gain, ADFI: Average daily feed intake

levels of neem leaf meal (NLM) in the diets. Decreased values recorded for final weight, weight gain and average daily weight gain could be attributed to low feed intake by the birds in treatments containing increasing levels of NLM probably due to residual anti-nutrients in the test material. Obun *et al.*[22] had previously reported a decrease in the feed intake with increasing levels of NLM in starting broilers. Feed conversion ratio was between 1.49 and 1.58 and was not significantly ($p>0.05$) different between dietary treatments.

At the finisher phase, weight gain, average daily weight gain, average daily feed intake and feed conversion ratio were significantly ($p<0.05$) influenced by dietary treatments. Birds fed diet containing 2.5% NLM recorded highest ($p<0.05$) value for weight gain (1244.67 g/bird), average daily weight gain (27.33 g/bird). Least value of weight gain (450.33 g/bird/bird), average daily weight gain (16.00 g/bird) were obtained in birds fed diet containing the 7.5% NLM. Decreased values could be attributed to less feed intake by birds in diets containing NLM probably due to less palatability of neem. Decrease in feed intake with increasing levels of NLM was previously reported by Bonsu *et al.*[23]. Final weight was not significantly ($p>0.05$) influenced. Both at the starter and finisher phases, mortality rates were recorded. The percentage mortality decreased with increasing levels of NLM in the diets. Feed conversion ratio ranged between 2.96 and 4.70 at the finisher phase. Birds fed diet containing NLM at 2.5% showed the best FCR of 2.96 which had the best performance in regard to weight gain at this final phase of the study.

Table 7: Carcass characteristics, cut-up parts and internal organs of broiler chickens fed dietary levels Of neem leaf meal

Parameters	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)	SEM
Live weight (g/bird)	1219.00	1159.33	998.00	1025.67	137.91
Plucked weight (g/bird)	1133.67	1064.67	919.67	948.67	132.81
Eviscerated weight (g/bird)	966.00	893.33	775.00	797.67	111.15
Dressing (%)	79.33	77.00	78.00	77.37	1.10
Major cut-up parts and other cuts (LW %)					
Head	4.00	4.00	4.00	4.67	0.33
Wings	13.00	12.33	12.00	12.67	1.07
Breast	22.33	20.67	20.33	19.67	1.39
Neck	6.67	6.67	6.67	7.00	0.65
Shanks	6.33	6.33	6.67	6.67	0.53
Drumstick	12.33	12.67	12.33	12.67	1.05
Thighs	14.00	14.00	14.33	14.33	1.06
Back	17.00	17.00	17.33	19.33	1.55
Internal organs (LW %)					
Gizzard	3.00	3.00	3.33	3.67	0.24
Heart	0.33	0.30	0.67	0.33	0.28
Lungs	0.67	0.33	1.00	0.67	0.28
Liver	2.00	1.67	2.00	2.33	0.24
Abdominal fat	2.00	1.00	1.67	2.00	0.33
Kidney	0.67	1.00	1.00	1.00	0.17
Small intestine length (cm)	183.33	194.33	152.67	145.00	14.79
Large intestine length (cm)	9.00	9.00	8.00	9.33	0.60
Small intestine weight	5.00	5.67	4.67	5.00	0.62
Large intestine weight	0.01	0.01	0.01	0.01	0.001
Caecal weight	0.01	0.01	0.01	0.01	0.001
Caecal length (cm)	30.33	32.00	24.33	28.33	1.53

T_1: Treatment 1 (Control-without Neem Leaf Meal), T_2: Treatment 2 (2.5% Neem Leaf Meal Inclusion), T_3: Treatment 3 (5% Neem Leaf Meal Inclusion), T_4: Treatment 4 (7.5% Neem Leaf Meal Inclusion), SEM: Standard error of means

Carcass characteristics: The carcass characteristics, cut-up parts and internal organs of broiler chickens fed dietary levels of neem leaf meal are presented in Table 7. The results recorded no significant ($p>0.05$) differences across dietary treatments. This suggested that increasing NLM across treatments did not affect the carcass characteristics of broiler chickens. Bonsu *et al.*[23] reported in their previous study, that the overall carcass characteristics were not significantly influenced by NLM in the diets of broilers. Results for cut-up parts showed no significant ($p>0.05$) effect of dietary treatments with the following ranges in relative terms (Live weight (%)) of cut up parts as breast (19.67-22.33%), drumstick (12.33-12.67%), thigh (14.00-14.33%) and back (17.00-19.33%). This outcome disagreed with the findings of Obun *et al.*[22] who reported significant ($p<0.05$) difference in the cut-up parts of broiler chickens fed NLM across all dietary treatments. The non-significance ($p>0.05$) effect could be due to the lack of detrimental effect of NLM in the study as the birds were not adversely affected by increased levels of NLM in the diets. The results for internal organs followed similar pattern as in the cut-up parts. These showed no significant ($p>0.05$) difference

and could be attributed to effective utilization of the diets by the broiler chickens. Bonsu *et al.*[23] had previously reported that there was no significant (p>0.05) effect of NLM diets on the percentage of internal organs of broilers across dietary treatments.

CONCLUSION

The results have indicated that most of the parameters recorded no significant (p>0.05) differences between treatments. This shows that Neem Leaf Meal when included at these different levels of inclusion may not have adverse effect on the performance, carcass and internal organ characteristics of broiler chickens. However, from the findings of this study, T_2 (2.5% NLM) inclusion level recorded the best performance in terms of total weight gain. It therefore shows that inclusion levels greater than 2.5% of Neem Leaf Meal might exacerbate negative effects on the weight gain of broiler chickens without affecting other vital parameters. The advantage of using NLM as a growth promoter is that the neem plant is readily available and the leaves can easily be harvested at relatively no cost. Preparation of NLM itself involves simple air drying at no cost.

FUTURE RECOMMENDATION

Based on the results of this study, it is therefore recommended that neem leaf meal (NLM) could serve as an alternative plant protein source and natural growth promoter in broiler chickens. The inclusion level of 2.5% is further recommended as adequate to be adopted by broiler farmers for optimum production.

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