Journal of Agriculture and Ecology Research International

12(4): 1-7, 2017; Article no.JAERI.33949
ISSN: 2394-1073

Effect of Graded Levels of Vitamin D_3 (Cholecalciferol) on the Performance, Carcass and Organ Weights of Broilers Chickens

B. B. Okafor[1] and G. A. Kalio[1*]

[1]Department of Agricultural Science, Ignatius Ajuru University of Education, Ndele Campus, P.M.B. 5047, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration between the authors. Author BBO designed the study, performed the statistical analysis, carried out the experiment and wrote the protocol. Author GAK wrote the first draft of the manuscript, managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2017/33949
Editor(s):
(1) Krzysztof Skowron, Department of Microbiology, Nicolaus Copernicus University in Torun, Collegium Medicum of L. Rydygier in Bydgoszcz, Poland.
Reviewers:
(1) Sabri Gül, Mustafa Kemal University, Turkey.
(2) Armando Cuéllar Cuéllar, Havana University, Cuba.
(3) Abdullahi M. Nuhu, Kaduna polytechnic, Nigeria.
(4) Akapo Olajetemi Abiola, Federal University of Agriculture Abeokuta, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/20764

Original Research Article

Received 5th May 2017
Accepted 28th May 2017
Published 1st September 2017

ABSTRACT

A 56 - day study to determine the effects of graded levels of cholecalciferol (Vitamin D_3) on performance, carcass and organ weights of broiler chickens was conducted. Two hundred and forty day old Marshall Broiler chickens were weighed and randomly placed into twelve pens in a completely randomized design. There were four treatment groups and three replicates for each treatment. Sixty birds were allotted to each treatment group. Treatment A contained 0% of vitamin D_3 (control) in the broiler vitamin/ trace mineral premix used to formulate the experimental broiler starter and finisher diets. Treatments B, C and D contained 40%, 80% and 100% inclusion of vitamin D_3 respectively. The birds were weighed weekly to determine weight gains. Daily feed consumption was taken and feed conversion ratio determined weekly. At the end of the 56-day performance study, six birds per treatment of two per replicate were slaughtered, defeathered and eviscerated to determine dressed carcass and organ weights (liver, gall bladder, gizzard, spleen

**Corresponding author: E-mail: ag.kalio@yahoo.com;*

and heart). Body weight gains and feed conversion ratio were not significantly ($P > 0.05$) different. However there was a significant ($P < 0.05$) difference in the weight of the gizzards at the 80% and 100% inclusion levels. Birds fed 100% inclusion levels of vitamin D_3 in their diet had the highest carcass weight. It was concluded that the inclusion of 100% vitamin D_3 in the broiler vitamin/ trace mineral premix as formulated and recommended by the manufacturers for broiler rations was adequate.

Keywords: Vitamin D_3 (Cholecalciferol); performance; carcass weight; organ weight and broilers.

1. INTRODUCTION

Broilers are fast growing chickens raised specifically for meat production. Their diets must be formulated to provide all of the birds' nutrient requirements if optimum growth and production are to be achieved. One of such essential nutrients needed by chickens is vitamins. Vitamins such as vitamins A, D_3, E, folic acid, pantothenic acid, pyridoxine and riboflavin are essential for the proper growth and health of the birds. Increased vitamin supplementation in broiler diets significantly improved broiler performance, carcass composition as well as reduced the negative impact of stress on them [1].

Cholecalciferol (Vitamin D_3) is one of the major types of vitamin D needed in broiler diets. It is the most important and biologically active form of vitamin D produced by irradiation of 7-dehydrocholesterol [2]. The intensively managed broiler chicks have no exposure to sunlight as well as the possibility of a photochemical reaction in the skin. Hence their feed has to be supplemented with adequate amounts of vitamin D. The common commercial source of vitamin D activity for poultry nutrition in its crystalline form is cholecalciferol (vitamin D_3) [3]. This metabolite must undergo additional changes in the liver to become 25-hydroxycholecalciferol (25-OH-D_3) and in the kidney to become 1, 25-dihydroxycholecalciferol which is considered as the active metabolite in the body of the animal [2].

Synthetic forms of Vitamin D_3 (Hy.D®) are available and are in use by poultry farmers. They are metabolites of vitamin D (25-hydroxycholecalciferol) which provides a more bioactive form of vitamin D_3 [4]. It is needed for the proper absorption of calcium from the intestines and kidney as well as aid absorption of phosphorus from the intestines [2]. Research has shown that the use of 25-hydroxycholecalciferol results in more chicks hatched and the production of more hatchable eggs. It was also shown to improve body weights and bone ash [5]. Vitamin D_3 is necessary to prevent rickets in growing chicks and to prevent a condition known as leg paralysis that accompanies the production of soft-shelled eggs in laying birds [6].

The minimum vitamin D_3 requirement as listed by [7] is 200 IU/Kg of the diet for broilers but this recommendation is based on old studies, performed under controlled environment. Modern breeds of birds have a higher growth and production rate, thus they need a higher nutritional requirement to express their genetic potential. It is believed that higher levels of supplementation will result in higher production performance and carcass quality. Consequently, it is anticipated that compensation in additional levels of vitamin D_3 will allow for possible losses during the feed manufacturing process as well as the length and conditions of storage [8].

There is dearth of information on the adequate levels of vitamin D_3 inclusion rates in the diets of broilers in the humid tropics, considering the fact that some of it may have been lost with the passage of time and storage of the feed [9]. This situation calls for an investigation into the effects of graded levels of vitamin D_3 in the diet on the performance, organ and carcass weights of broilers that can be recommended for use in the South-south geographical region of Nigeria.

2. MATERIALS AND METHODS

2.1 Location of the Experiment

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm, Rivers State University of Science and Technology, Port Harcourt. The farm is situated on latitude 4°48'N and longitude 6°58'E of Rivers State, Nigeria.

2.2 Experimental Animals

A total of 240 day old Marshal Broilers obtained from Raman Tunde Olayiwola (RTO) Agric Farms Ltd, located at Osogbo, Osun State were used for the experiment. The day old chicks were weighed to obtain the initial body weight and thereafter, randomly allocated into twelve pens that had been cleaned and disinfected before housing the birds.

2.3 Experimental Diets

The treatments consisted of four dietary treatments labeled A, B, C, and D with three replications per treatment. The experimental diets were formulated with maize, palm kernel cake, soya bean meal, fish meal, bone meal, methionine, lysine, salt and broiler vitamin/trace mineral premix containing 0% vitamin D_3 for treatment A (control), 40% vitamin D_3 for treatment B, 80% vitamin D_3 for treatment C and 100% vitamin D_3 for treatment D. They were milled and mixed with the test vitamin premix containing the different levels of vitamin D_3 at a feed mill located at Elekahia, Port Harcourt, Rivers State.

The test vitamin premix with the different levels of vitamin D_3 was obtained from Nutrivitas Ltd, Lagos, Nigeria. This was administered in the experimental diets (Treatments A, B, C and D) as shown in Table 1.

Two distinct broiler rations were formulated: the broiler starter and broiler finisher rations respectively. The treatment diets for each group had the same feed ingredients. Variations were in the test vitamin/trace mineral premix that contained the graded levels of vitamin D_3 in the diets. The composition of the experimental diets is shown in Table 2.

2.4 Experimental Procedure

The pens for the housing of the birds were prepared in anticipation for brooding of the birds using wood shavings as litter materials. On arrival, the birds were stabilized using antibiotics, multivitamins and glucose in their drinking water for five days. Chick drinkers and feeders as well as adult drinkers and feeders were provided for watering and feeding the birds during the starter and finisher phases. The experimental diets were fed to the birds for the duration of the experiment which was terminated on the 56th day.

Other routine management practices were carried out during the course of the experiment such as routine vaccinations against Newcastle disease at the 3rd and 6th week, and Gumboro at the 2nd and 4th week respectively. A prophylactic dose of coccidiostat was also administered via drinking water to control coccidiosis.

2.5 Birds and Experimental Design

After the birds were weighed to determine their initial weight, they were randomly assigned to 12 pens in a Completely Randomized Design (CRD). There were four dietary treatment groups of 60 birds per treatment with three replicates of 20 birds each.

2.6 Data Collection

Parameters measured included performance parameters (body weight, feed intake, feed conversion ratio, mortality), organ weights (gizzard, gall bladder, spleen, liver, heart) and dressed weight (carcass). Feed intake and mortality records were taken on daily basis. Body weight gains and feed conversions of birds per treatment were computed on weekly basis.

2.7 Evaluation of Broiler Performance Parameters

2.7.1 Feed intake

The feed offered to the birds in each replicate in each treatment group was weighed and the left over were weighed daily and recorded. Feed intake for each group was determined by the difference between the feed served and the left over feed.

Feed intake = weight of feed offered – weight of feed leftover.

Table 1. Test vitamin premix with graded levels of vitamin D3 inclusions

Dietary treatment	% inclusion of Vitamin D3	Vitamin D3 (UI/2.5 kg)	Vitamin D3 (UI/kg)
A (Control)	0	-	-
B	40	800,000	320,000
C	80	1,600.000	640,000
D	100	2,000,000	800,000

The Company's standard vitamin/trace mineral premix = 2,000,000 IU/2.5 kg Equivalent to 800,000 IU/kg

Table 2. Composition of the experimental diets

Ingredients	Broiler starter	Broiler finisher
Gross composition	**(%)**	**(%)**
Maize	55.00	55.00
Palm kernel cake	10.30	14.30
Soya bean meal	28.00	25.00
Fish meal	3.00	2.00
Bone meal	3.00	3.00
Methionine	0.10	0.10
Lysine	0.10	0.10
Salt	0.25	0.25
Vitamin/trace mineral premix	0.25	0.25
Total	**100.00**	**100.00**

2.7.2 Weight gain

The birds were weighed at the beginning of the experiment and the weights recorded as initial body weights. Subsequently, they were weighed weekly to determine their weekly body weight and weight gains were calculated there from.

Weight gain = final body weight – initial body weight

Daily body weight gain =

$$\frac{\text{Body weight gain}}{\text{Number of days of the experiment}}$$

2.7.3 Feed conversion ratio

The feed conversion ratio (FCR) was calculated by dividing the feed intake by the weight gain.

$$\text{Feed conversion ratio} = \frac{\text{feed intake}}{\text{Weight gain}}$$

2.8 Evaluation of Organ Weights

Two birds from each replicate making a total of six per treatment were sacrificed and eviscerated. The weights of the gizzard, gall bladder, spleen, heart and liver were taken and recorded for each bird.

2.9 Statistical Data Analysis

The results obtained were subjected to analysis of variance (ANOVA) [10]. Significant means were separated using the Duncan's New Multiple Range Test [11].

3. RESULTS AND DISCUSSION

3.1 Performance of Broilers Fed Experimental Diets Containing Varying Graded Levels of Vitamin D_3 (Cholecalciferol)

The performance characteristics of broilers fed graded levels of vitamin D_3 inclusion in the diet of broilers are presented in Table 3. There were significant (P < 0.05) differences in the average weekly feed intake.

The average weekly feed intake was highest for birds in treatment A with a value of 769.99±80.13 g/bird. This was followed by birds in treatment B with a value of 750.64±77.58 g/bird. Treatment C had the least value of 693.21±67.83 g/bird in average daily feed intake. The average daily feed intake for treatments A and B were significantly (P < 0.05) different from treatments C and D. There were numerical differences in the feed conversion ratio but these differences were not significant (P > 0.05). Treatment D tended to have an improved feed conversion ratio though it was not significant (P > 0.05). Mortality tended to decrease with increasing levels of vitamin D_3 inclusion.

The average weekly weight gain and total body weight were not significantly (P > 0.05) differently. However, the average weekly weight gain and total body weight values (267.50±48.61 g/bird and 2172.72±53.70 g respectively) were marginally highest in treatment A (0% inclusion of vitamin D_3) followed by birds in treatment B (40% inclusion of vitamin D_3) with a value of 253.38±48.47 g/bird. The average daily weight gain and total body weight was lowest in treatment C. The results recorded in this study were in agreement with the reports of [12] who observed significantly greater body weights in broilers fed diets incorporated with vitamin D_3 within the range of 1500 IU/Kg – 3500 IU/Kg than those incorporated with 200 IU/Kg vitamin D_3 in their feed. Similarly, [13] also observed a progressive increase in body weight of broilers fed graded levels of vitamin D_3 (200, 1200, 2400 and 3600 ICU/Kg). Furthermore, [2] observed that vitamin D_3 levels of approximately 1,000 IU/Kg were needed to maximize body weight of birds at 42 days. The higher average daily weight gain and total body weights recorded in this study were attributed to the increased amount of feed consumed by birds in treatment A.

Table 3. Effect of graded levels of vitamin D_3 on the performance of broilers

Parameters	Dietary treatments			
	A (0 UI/kg)	B (320,000 UI/kg)	C (640,000 UI/kg)	D (800,000 UI/kg)
Initial body weight (g)	38.00	38.00	38.00	38.00
Final body weight (g)	2172.72±53.70	2065.73±106.15	1942.76±66.59	2045.52±65.51
Average weekly weight gain (g/bird)	267.50±48.61	253.38±48.47	236.52±37.70	250.94±36.39
Average weekly feed intake (g/bird)	$769.99^{a}\pm80.13$	$750.64^{a}\pm77.58$	$693.21^{b}\pm67.83$	$709.23^{b}\pm 68.05$
Feed Conversion Ratio	2.88±0.34	2.96±0.40	2.93±0.15	2.82± 0.30
Mortality (%)	10.00	15.00	8.33	3.33

a, b – means within the same row carrying different superscripts differ significantly (P < 0.05)

Table 4. Effect of graded levels of vitamin D_3 on the carcass and organ weight of broilers

Parameters	Dietary treatments			
	A (0 UI/kg)	B (320,000 UI/kg)	C (640,000 UI/kg)	D (800,000 UI/kg)
Carcass weight (kg)	1.60 ± 0.10^{a}	1.63 ± 0.12^{ab}	1.37 ± 0.09^{b}	1.73 ± 0.02^{a}
Spleen (g)	2.33 ± 0.88	1.67 ± 0.67	2.50 ± 0.50	3.33 ± 0.88
Gizzard (g)	48.00 ± 0.51^{ab}	46.00 ± 2.88^{b}	46.00 ± 4.93^{b}	57.00 ± 2.51^{a}
Liver (g)	47.33 ± 6.11	46.67 ± 2.02	46.00 ± 4.93	57.00 ± 2.51
Heart (g)	10.67 ± 1.33	10.33 ± 0.88	10.67 ± 0.33	10.33 ± 2.18
Gall Bladder (g)	2.00 ± 0.57	2.00 ± 1.00	2.50 ± 0.50	1.50 ± 0.50

a, b – means within the same row carrying different superscripts differ significantly (P<0.05).

3.2 Carcass and Organ Weight of Broilers Fed Graded Levels of Vitamin D_3 (Cholecalciferol)

The effect of graded levels of vitamin D_3 on the carcass and organ weights of broilers is presented in Table 4. The carcass weight and weights of the following organs of the broilers were measured: the spleen, gizzard, liver, heart and gall bladder. There were significant ($P < 0.05$) variations in the carcass weight of the birds among the treatments. Birds in treatment D numerically had the highest carcass weight of 1.73 kg. This was followed by birds in treatment B with a carcass weight of 1.63 kg and birds in treatment A with a carcass weight of 1.60 kg. The least carcass weight of 1.37 kg was observed in birds in treatment C. The carcass weight of birds in treatment D differed significantly ($P < 0.05$) from birds in treatment C but did not differ significantly ($P > 0.05$) from birds in treatments A and B. There was no significant ($P > 0.05$) difference in the carcass weight of birds in treatments A and B. There were no significant ($P > 0.05$) variations in the spleen, liver, heart and gall bladder weights of the birds fed the experimental diets but numerical differences were observed. The treatments significantly ($P < 0.05$) influenced the gizzard weight of the birds. Birds in treatment group D had the highest mean weight of spleen (3.33 g), gizzard (57.0 g) and liver (57.0 g). The mean gizzard weight of birds in treatment D (57.0 g) was significantly ($P < 0.05$) different from those in treatments B and C but did not differ significantly ($P > 0.05$) from that of treatment A which had a mean weight of 48.0 g. Birds in treatments A and C had the same mean heart weight of 10.67 g but did not differ significantly ($P > 0.05$) from birds in treatments B and D which had a mean heart weight of 10.33 g. The mean weight of the gall bladder was highest for birds in treatment C (2.5±0.50). Birds in treatments A and B had a mean weight of 2.0 g and in treatment D, the mean gall bladder weight was 1.5 g but these weights did not differ significantly ($P > 0.05$).

The values obtained for the carcass weight of the birds in treatments A, B and C were in agreement with [14] who showed that the dressing percentage and breast meat yield were better in birds fed diets containing 2500 or 3500 IU/Kg vitamin D_3. However, these values were even below those used for the experimental diets in this study.

Birds in treatment groups C were observed to have the highest gall bladder weight. Vitamin D_3 is usually absorbed from the intestine in association with fats and requires the presence of bile salts for absorption. Bile salts are produced in the gall bladder. Thus, higher levels of vitamin D_3 in the diet may have lead to higher activity in the gall bladder, thus giving rise to higher weights.

The weights of the gall bladders of birds in treatment groups A and B were also high as compared to treatment group D where the gall bladder had the smallest size which could be due to minimal level of vitamin D_3 activity since the diet in treatment group A did not include vitamin D_3.

Similarly, birds in treatment D had numerically the highest liver weight. This could be as a result of high level of metabolic activity in the liver. It has been stated that vitamin D_3 once absorbed in the small intestine is transported to the liver where it is hydroxylated to the active metabolite, 25-hydroxycholecalciferol [2]. The function of the liver is for detoxification. The marginally higher weight of liver in treatment D (100% vitamin D_3) when compared to the control and other treatment groups could be attributed to the detoxification function of the liver that led to its enlargement. Studies have shown that 25-hydroxycholecalciferol has twice the activity of vitamin D_3 and that 1, 25 dihydroxycholecalciferol is not approved by the food and drug administration to be added to feeds [4]. The highest vitamin D_3 inclusion (Treatment D) tended to produce numerically heavier organs in terms of spleen, gizzard and liver when compared to the control (0% vitamin $D_{3)}$. However, the gall bladder weight of treatment D birds tended to be suppressed by higher vitamin D_3 levels in the diet. This may be due to metabolic activities of these organs to combat the higher levels of vitamin D_3.

4. CONCLUSION AND RECOMMENDATION

Vitamin D_3 (cholecalciferol) is an essential fat soluble vitamin and it plays an important role in the metabolism of calcium and phosphorus. The active metabolite, 1, 25 dihydroxycholecalciferol is produced by the hydroxylation of 25-hydroxycholecalciferol in the kidney.

Supplementation of vitamin D_3 in the diets of intensively housed poultry birds is essential since the birds are not exposed to ultraviolet light from the sun which produces the compounds of vitamin D_3 in a photochemical reaction.

Only some of the feed ingredients used in the production of poultry feed such as fishmeal may contain a rich source of vitamin D_3. Minimum inclusion levels of vitamin D_3 are aimed to meet the total requirements to prevent defects of calcification in both young chickens and adult birds.

The NRC recommends a minimum dose of 200 IU/Kg vitamin D_3 in poultry feed. This study was done to determine the effects of graded levels of vitamin D_3 on the performance and organ weights of boiler chickens.

Results of this study showed that increasing the levels of vitamins D_3 in the diet resulted in improved dressed weight and feed conversion and utilization of the broiler chickens. The gizzard showed significant increase in weight with increasing levels of vitamin D_3 in the diet.

From this study, inclusion of vitamin D_3 in poultry diets at levels normally used by the manufacturers (2,000,000 IU vitamin D_3 /2.5 Kg = 800,000 IU/Kg) is recommended for commercial broiler production. This is based on the observation that the dressed carcass weights were better in treatment group D than the other treatment levels. The gizzard weight was also significantly higher in treatment D. Feed conversion was also more improved. The gizzard is a delicacy and higher weights would attract better financial gains.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Paul RC, Ahmad N, Moinuddin MA, Hasan N. Effects of administration of multivitamins and enzymes for broilers either singly or in combination on body weight and haematobiochemical parameters. Journal of the Bangladesh Agricultural University. 2010;8(1):39-44.
2. Fritts CA, Waldroup PW. Effect of source and level of vitamin D on live performance and bone development in growing broilers. Journal of Applied Poultry Research. 2003;12(1):45-52.

3. Chou SH, Chung TK, Yu B. Effects of supplemental 25 hydroxycholecalciferol on growth performance, small intestinal morphology, and immune response of broiler chickens. Poultry Science. 2009;88: 2333–2341.
4. Jensen LS. Poultry: Vitamin D. Animal Nutrition and Health. DSM Nutritional Products, North America; 2011.
5. Ward NE. The use of 25-hydroxy vitamin D_3 for meat poultry. DSM Nutritional Products. Inc. Parsippany NJ; 2003.
6. Robinson D. Understanding vitamins for poultry; 2011. Available:www.dsm.com/en_-us/html/dnpna/anh-poul-rit-d-def.htm (Retrieved on 23/10/2016)
7. National Research Council (NRC). Nutrient requirements of poultry. 9th Revised Edition. Washington, DC. National Academy Press; 1994.
8. Maiorka A, Felix AP. Broiler diets demand balanced vitamin supplementation. World Poultry; 2010. Available:www.worldpoultry.net/Broilers/ (Retrieved on 23/10/2016)
9. McDowell LR. Vitamins in animal and human nutrition (2nd Edition). Iowa State University Press, Ames, IOWA; 2000.
10. Steel RGD, Torrie JH. Principles and procedures of statistics. Biometric approach. (2nd Ed.) McGraw Hill Co. Inc., New York, USA; 1980.
11. Statistical Analysis System User's Guide (SAS). SAS/STAT Version (8th Edition). SAS Institute. Inc. Cary, NC, USA; 2001.
12. Rama SV, Raju MVLN, Panda AK, Reddy MR. A practical guide to vitamin D nutrition in poultry- A review of the functions of cholecalciferol in poultry and how it interacts with other dietary, environmental and genetic factors, together with requirements and toxicity; 2007. Available:www.wattagnet.com (Retrieved on 22/10/2016)
13. Kahn KA, Akram J, Fazal M. Hormonal actions of vitamin D and its role beyond just being a vitamin: A review article. International Journal of Medicine and Medical Sciences. 2011;3(3):65-72.
14. Kahn SH, Shahid R, Mian AA, Sardar R, Anjum MA. Effect of the level of cholecalciferol supplementation of broiler diets on the performance and tibial dyschondroplasia. Journal of Animal Physiology and Animal Nutrition. 2010;94(5):584-593.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20764