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Evaluation the Effects of Dietary Cholecalciferol Substitution with 1alpha-Hydroxycholecalciferol on Performance and Tibia Parameters in Broiler Chickens

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Abstract: This experiment in broiler chickens was conducted to test the efficacy of feeding 1alpha-OH D_3 as a replacement for cholecalciferol on performance, tibia quality and severity of tibial dyschondroplasia (TD). On the day of hatch 96 as hatched broiler chickens (Ross-308) were weighted and randomly allocated to two treatment groups, each with 4 replicate pens of 12 chicks. The dietary treatments were as follows: basal diet+5 μg/kg of 1alpha-OHD_3, or basal diet+5000 IU/kg vitamin D_3. The broiler house was completely enclosed and lighting was provided by incandescent bulbs. No significant differences ($p>0.05$) were observed on daily feed intake, body weight and feed conversion ratio whereas it tended to improve in broilers fed basal diet supplemented with 5 μg/kg of 1alpha-OHD_3 diet ($p>0.05$). No significant differences ($p>0.05$) were found between broilers fed basal diet plus 1alpha-OHD_3 or the same basal diet plus cholecalciferol for any of tibia variables measured, whereas it tended to increase in broilers fed basal diet supplemented with 5 μg/kg of 1alpha-OHD_3 ($p>0.05$). Treatments failed to induce any effect on TD scores at d 42, though it tended to increase in broilers fed diets containing 5 μg/kg of 1alpha-OHD_3 ($p>0.05$). In conclusion, the results indicate that supplementing 1alpha-OHD_3 as a replacement for cholecalciferol could promote performance and tibia parameter and it increased severity of TD, whereas the results were not statistically significant.

Key words: Cholecalciferol, 1alpha-hydroxycholecalciferol, performance, tibia parameters, broiler

INTRODUCTION

It has been shown that dietary addition of 1.25-dihydroxyvitamin D, but not vitamin D itself, reduced the incidence of tibial dyschondroplasia (TD) in broilers (Whitehead, 1995). Several experiments indicated positive effects of dietary addition of 25 $(OH)D_3$ on performance (Fritts and Waldroup, 2003) and incidence of TD in broilers (Zhang *et al*., 1997) thus, its authorized for use in poultry nutrition. As an analog of vitamin D, it is possible that 1alpha-OH D_3 become a feed additive in future. Haussler *et al*. (1973) described the ability of 1alpha-OH D_3 to replace cholecalciferol in young chickens and later in another trial Edwards *et al*. (2002) found that its activity is approximately eight times as effective as cholecalciferol. Nowadays, synthesis of 1.25-$(OH)_2D_3$ is not cost effective for use in poultry feed. However, Biehl *et al*. (1998) reported that the 1alpha-OHD_3 analogue could be synthesized at less than 1% of the cost of 1.25-$(OH)_2D_3$, although according to the data reported by Boris *et al*. (1977) its efficacy in promoting bone ash is equivalent to 1.25-$(OH)_2D_3$.

This experiment in broiler chickens was conducted to test the efficacy of feeding 1alpha-OH D_3 as a replacement for cholecalciferol. Parameters included performance indices, tibia quality and severity of TD.

MATERIALS AND METHODS

Animals and dietary treatments: On arrival, 96 as hatched broiler chickens (Ross-308) were weighed individually and assigned randomly to each of the 4 treatment groups, each with 4 replicate pens of 12 chicks. The starter, grower and finisher diets in mash form were fed from 0 to 14 d, 14 to 28 d and 29 to 42 d of age, respectively. Table 1 lists the basal diet formulated to meet or exceed the nutrient requirements of broilers except for vitamin D_3 (Aviagen, 2009). The dietary treatments were as follows: basal diet+5 μg/kg of 1alpha-OHD_3 (Vitamin Derivatives Inc., Georgia, USA), or basal diet+5000 IU/kg vitamin D_3 (DSM Swiss). Chicks were raised on floor pens (120 x 120 x 80 cm) and feed and water were provided *ad libitum*. The broiler house was completely enclosed and lighting was provided by incandescent bulbs to prevent birds from being exposed to ultraviolet radiation and synthesizing their own vitamin D. The lighting program was provided for 24 h light and 1 h of darkness throughout the experiment. The experimental house temperature was controlled at 32°C during the first week and then gradually reduced by 3°C/week to finally fixed at 22°C.

Performance parameters: Average pen weights of broilers were recorded at the start of the study, 14, 28

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Table 1: Ingredient and calculated composition of experimental diets

Item	Starter	Grower	Finisher
Corn	545.5	576.7	627.62
Soybean meal	397	365	320
Soybean oil	11.7	20	16.6
Monocalcium phosphate	15.4	13	11.85
$CaCO_3$	16.7	14.4	13.7
NaCl	3.2	3.2	3.2
Trace mineral premix[1]	2.5	2.5	2.5
Vitamin premix[2]	2.5	2.5	2.5
DL-Methionine	3	2.2	1.84
L-Lysine	2.1	0.5	0.19
L-Threonine	0.5	-	-
Calculated composition			
ME, kcal	2.850	2.950	2.978
CP (%)	22.7	21.2	19.53
Calcium (%)	1	0.85	0.795
Phosphorus-total (%)	0.718	0.651	0.609
Nonphytate P (%)	0.483	0.424	0.393

[1] Provided the following per kg of diet: Mg, 56 mg; Fe, 40 mg; Cu, 16 mg; Zn, 100 mg; Co, 125 mg; I, 1.25 mg

[2] Provided the following per kg of diet: vitamin A, 11,000 IU; vitamin D_3, 5000 IU; vitamin E, 75 IU; vitamin K, 3 mg; riboflavin, 8 mg; vitamin B_{12}, 0.016 mg; pantothenic acid, 15 mg; nicotinic acid, 60 mg; folic acid, 2 mg; choline, 3 mg

and 42 d of age. Mortality was recorded daily throughout the experiment. Daily body weight gain (DWG) and daily feed intake (DFI) were recorded in different periods and feed conversion ratio (FCR) was calculated and adjusted for mortality.

Chemical analysis: At 42 d of age, 2 birds per pen were chosen, based on the average weight of the group and killed by cervical dislocation and the left tibia from each bird was collected for bone ash analysis on a dry fat-free basis (method 22.10; AOAC, 1995). Calcium and P contents of tibia ash were analyzed by the ICPOES method 2011.14 (AOAC, 1990). Their right tibias were used to determine the incidence and severity of (tibial dyschondroplasia) TD using the 0 to 3 scoring system as described by Edwards and Veltmann (Edwards and Veltmann, 1983).

Statistical analyses: The data were subjected to analysis of variance procedures appropriate for a completely randomized design using the General Linear Model procedures of SAS (SAS Inst. Inc., Cary, NC). Means were compared using Tukey test. Statements of statistical significance are based on $p<0.05$.

RESULTS

Growth performance: Data on performance indices are summarized in Table 2. No significant differences ($p>0.05$) were observed on DFI and body weight (BW) whereas it tended to increase in broilers fed basal diet supplemented with 5 µg/kg of 1alpha-OHD_3 diet. Broilers receiving 5 µg/kg of 1alpha-OHD_3 had lower FCR compared to broilers fed diet supplemented with cholecalciferol during starter, grower, finisher periods and entire experimental period, whereas the results were not statistically significant ($p>0.05$).

Table 2: Effect of experimental diets on performance indices of broilers at different ages

	---------- Dietary treatments ----------		
Variables	1alpha-OH-D_3	Cholecalciferol	SEM[1]
Body weight (g)			
14 d	275	241	12
28 d	1000	983	36
42 d	1966	1816	47
Daily feed intake (g/d)			
0-14 d	23.29	20.52	1.1
14-28 d	89.65	89.70	2.79
28-42 d	135.57	132.73	7.6
0-42 d	83.00	64.72	6.49
Feed:gain (g:g)			
0-14 d	1.40	1.43	0.09
14-28 d	1.74	1.69	0.08
28-42 d	2.19	2.23	0.16
0-42 d	1.81	1.88	0.05

[a,b]Values in the same row not sharing a common superscript differ ($p<0.05$)

[1]Standard error of mean

Parameters of tibia: Data on tibia quality are summarized in Table 3. No significant differences ($p>0.05$) were found between treatments for tibia length, weight and diameter. No significant differences ($p>0.05$) were found between broilers fed basal diet plus 1alpha-OHD_3 or the same basal diet plus cholecalciferol for tibia ash, Ca and P values, whereas it tended to increase in broilers fed basal diet supplemented with 5 µg/kg of 1alpha-OHD_3. Treatments failed to induce any marked effect on TD scores at d 42, though it tended to increase in broilers fed diets containing 5 µg/kg of 1alpha-OHD_3 ($p>0.05$).

DISCUSSION

In the present trial no significant differences were found between broilers fed basal diet plus 1alpha-OHD_3 or the same basal diet plus cholecalciferol for performance criteria, whereas it tended to improve in broilers fed basal diet supplemented with 1alpha-OHD_3. Edwards *et al.* (2002) reported that 1alpha-OHD_3 could substitute cholecalciferol in broilers diets and its increases BW, DFI and FCR. Biehl and Baker (1997) reported that addition of 1alpha-OH D_3 enhanced the BW of chickens fed P-deficient and adequate in vitamin D_3, but in purified diets with adequate vitamin D_3, it had no effect on BW, which suggests that 1alpha-OH D_3 might increase BW of broilers by enhancing Phytate Phosphorus (PP) utilization. Further study indicated that PP retention increased with the supplementation of 1alpha-OH D_3 in broilers on d 1 to 16 (Edwards *et al.*, 2002).

In the present trial no significant differences were found between broilers fed basal diet plus 1alpha-OHD_3 or the same basal diet plus cholecalciferol for tibia ash, Ca and p-values, whereas it tended to increase in broilers fed basal diet supplemented with 1alpha-OHD_3. Haussler *et al.* (1973) reported that 1alpha-OHD_3 could substitute cholecalciferol in broilers diets. Edwards *et al.* (2002) reported that the activity of 1alpha-OHD_3 for satisfying the nutrient requirement of broiler chickens is

Table 3: Effect of experimental diets on tibia parameters of broilers at 42 d

	Tibia parameters						
Dietary treatments	Weight (g)	Length (cm)	Diameter (cm)	Tibia ash (%)	Calcium (%)	Phosphorus (%)	TD score
Cholecalciferol	5.44	9.15	0.60	44.22	16.00	8.14	0.50
1alpha-OH-D_3	5.62	9.38	0.59	45.45	16.55	8.29	1.16
SEM*	0.30	0.13	0.04	0.52	0.23	0.11	0.32

[a,b]Values in the same column not sharing a common superscript differ ($p<0.05$). *Standard error of mean

eight times as effective as cholecalciferol based on tibia ash. In another trial supplementation of 1alpha-OHD_3 to insufficient vitamin D_3 broiler breeders' diet resulted in equivalent egg production, egg shell quality and hatchability and it couldn't improve parameters measured because of broiler breeders' ability to metabolize sufficient 1.25 $(OH)_2D_3$ rom dietary cholecalciferol (Mottaghitalab *et al*., 2013). In the present trial treatments failed to induce any marked effect on TD scores at d 42, though it tended to increase in broilers fed diets containing 5 µg/kg of 1alpha-OHD_3 ($p>0.05$). Lofton and Soars (1986) reported that feeding very high level of cholecalciferol (up to 20,000 IU/kg of diet) to broilers and later in another trial Edwards (1989) reported that supplementation of 1.25 $(OH)_2D_3$ to broiler chickens fed low calcium diet decreased the incidence of TD. Similarly, in another our trial addition of 5 µg 1alpha-OHD_3/kg to Ca-P deficient diet without vitamin D_3 increased tibia ash, Ca and P values and incidence and severity of TD than those fed Ca-P adequate diet contained cholecalciferol and no added 1alpha-OHD_3/kg (unpublished data). It seems that in the present study supplementing 1alpha-OHD_3 as a replacement for cholecalciferol increased severity of TD as a result of more mineralization of tibia.

Conclusion: In conclusion, the results indicate that supplementing 1alpha-OHD_3 as a replacement for cholecalciferol could promote performance and tibia parameters and it increased severity of TD, whereas the results were not statistically significant. Further studying are require to determine the optimum level of feeding 1alpha-OHD_3 as a replacement for cholecalciferol or feeding 5 µg/kg of 1alpha-OHD_3 as a replacement for cholecalciferol to Ca deficient dies.

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