Performance and tibia bones quality in broilers fed diet supplemented with particulate limestone and 25-hydroxycholecalciferol

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Abstract

In the experiment carried out on 560 broiler chickens, the effect of diet supplementation with particulate limestone (grit, diameter 1.2-4 mm) and 25-hydroxycholecalciferol (25-OH-D_3) on performance and selected biomechanical parameters of tibia bones was studied. Replacement of 30% pulverized limestone by grit positevely affected chicken performance and ultimate load, yielding load and stiffness of tibia bones at 43 days of age. Replacement of cholecalciferol by 25-OH-D_3 at level of 50 and 60% had positive effect on body weight gain and feed conversion. Partial or complete substitution of 25-OH-D_3 for cholecalciferol increased yielding load and stiffness of bones.

Introduction

Adequate dietary levels of calcium, phosphorus and vitamin D are required for chickens growth and normal bone development. Guinotte et al. (1991) found that utilization of calcium carbonate sources by the chick is rather a result of particle size than origin. As compared to ground calcium carbonate (<0.15 mm) coarse particles (>1.18 mm) incorporated to the diet diminished weight gain and feed conversion, tibia characteristics and ash content, and decreased calcium retention (Guinotte et al., 1991). In contrast, Zohravi (2002) incorporating coarse particle size (1.18-4.75 mm) limestone to broiler diet significantly improved feed conversion ratio, tibia ossification and Ca and P retention.

Vitamin D_3 is generally added to diets in the form of cholecalciferol, but in order to carry out its physiological function must be hydroxylated in two-step process: in liver (to 25-OH-D_3) and in kidney (to 1, 25-OH-D_3). High incidence (40-80%) of tibial dyschondroplasia (TD) in commercial broilers (Whitehead, 1995) may suggests, that this process is not sufficient. It was stated, that birds fed diets supplemented with 25-OH-D_3 had greater body weight and bone ash at 21 and 42 days of age and significantly lower incidence and severity of tibial dyschondroplasia (Frits and Waldroup, 2003; Yarger et al., 1995)..

The aim of the study was to evaluate the effect of particulate limestone and 25-OH-D_3 substitution for pulverized limestone and cholecalciferol in broiler chicken diet on performance and selected biomechanical characteristics of tibia bones.

Materials and Methods

A 6-week experiment was carried out on 560 Cobb broiler chickens. Sexed day-old's were allotted to 14 groups in 5 replicates of 8 chickens each (4 male and 4 female) kept together in cages with wire mesh floors. Experiment consisted of a 5 x 2 factorial arrangement with two forms of limestone and seven vitamin D_3 and 25-OH-D_3 ratios in the diet. Corn and soybean meal based starter (1-21 day) and grower-finisher (22-43) diets with standard level of all nutrients contained pulverized limestone (0.9% of diet) or mixture of 70% of pulverized and 30% of particulate (1.4-4 mm diameter) limestone as a source of calcium. Both forms of limestone were mined from Lower Carbon layers of compact limestone of organic origin in Czatkowice near Kraków. Both types of diets were supplemented with 2000 (starter) or 1500 (grower-finisher) I.U. of vitamin D_3 (cholecalciferol) and 25-OH-D_3 (Hy-D Beadlet, DSM) was substituted in equivalent amounts of 0, 20, 40, 60, 80 and 100 % for cholecalciferol.

Body mass, feed intake and mortality was observed and body weight gain and feed conversion were calculated for whole experimental period. On base of BWG, FC and mortality the European performance efficiency index (EPE-index) was calculated. At the end of experiment (43 days of age), 8 birds (4 male and 4 female) from each group were sacrificed by decapitation. The tibias from both legs were prepared, cleaned of soft tissues, weighed and stored frozen (-25ºC) until analysis. Biomechanical properties of bones (maximum load, yielding load and stiffness) in three point bending test were determined, using Instron 5542 Testing Machine (a constant speed of head – 10 N/min, distance between supports – 50 mm).

Obtained data were subjected to statistical analysis using two-way factorial analysis of variance. Significance of differences between means was determined by Duncan's multiple range test (Statistica 5.0 PL).

Results and discussion

Partial replacement of pulverized limestone by particulate limestone significantly improved body weight gain, feed conversion and EPE-index (Table 1). These findings agree with results of Zohravi (2002) who used 0.6 to 1.18 and 1.18 to 4.75 mm particle sized limestone *versus* less than 0.15 mm. Results partly are in contrast to study of Guinotte et al. (1991) who used coarse particles of limestone (greater than 1.18 mm) as a sole source of Ca added to the diet. Substitution of 25-OH-D_3 for cholecalciferol at level of 50 and 60% also positively affected performance parameters. EPE-index improvement was observed when 25-OH-D_3 was substituted at level of 50, 60 and 100% for cholecalciferol. The improvement of body weight in chickens fed equivalent amount of 25-OH-D_3 as a complete substitute for D_3 was stated by Fritts and Waldroup (2003) at 125-1000 IU D_3 in the diet.

Table 1. Effect of grit and 25-OHD3 on the performance of chickens (1-42 days of age)

% of 25-OH-D_3 in whole amount of added vitamin D_3	Body weight gain g			Feed intake g			Feed conversion Kg			Performance efficiency index		
	% of grit in whole amount of used calcium carbonate											
	0	30	**Mean**	0	30	**Mean**	0	30	**Mean**	0	30	**Mean**
0	2191	2270	**2231^{a}**	3910	3898	**3904**	1.78	1.72	**1.75^{c}**	296	319	**308^{a}**
20	2204	2280	**2242^{ab}**	3857	4019	**3938**	1.75	1.76	**1.76^{c}**	304	313	**309^{a}**
40	2146	2318	**2232^{a}**	3770	4002	**3886**	1.76	1.73	**1.74^{bc}**	295	324	**309^{a}**
50	2311	2349	**2329^{bc}**	3973	3871	**3923**	1.72	1.65	**1.68^{a}**	324	344	**334^{b}**
60	2310	2373	**2341^{c}**	3944	3992	**3968**	1.71	1.68	**1.69^{a}**	326	340	**333^{b}**
80	2262	2334	**2298^{abc}**	3914	3996	**3955**	1.73	1.71	**1.72^{abc}**	316	329	**322^{ab}**
100	2277	2356	**2317^{abc}**	3890	4002	**3947**	1.71	1.70	**1.70^{ab}**	322	334	**328^{b}**
Mean	**2243^{x}**	**2326^{y}**		**3895**	**3969**		**1.74^{x}**	**1.71^{y}**		**312^{x}**	**328^{y}**	
SEM	12.9			21.3			0.00626			2.48		

Effect of:	Body weight gain	Feed intake	Feed conversion	Performance efficiency index
Ca source	***	NS	***	***
Vitamin D_3	*	NS	***	***
Interaction	NS	NS	NS	NS

x, y – values in the rows with different letters differ significantly ($P \leq 0.05$); a, b, c – values in the columns with different letters differ significantly ($P \leq 0.05$); NS – $P>0.05$; * - $P \leq 0.05$; *** - $P \leq 0.001$

Replacement of 30% of pulverized limestone by grit significantly increased ultimate load, yielding load and stiffness of tibia bones (Table 2). Zahravi (1991) noted, that use of medium or coarse particle limestone significantly improved tibia ossification characteristics -

as compared to finely ground calcium. Guinotte et al. (1991) observed however negative effect of coarse particle limestone on ash percent and physicial parameters of tibias. The reason for this differences was probably in substitution level of ground limestone, Guinotte et al. (1991) replaced 100% but in our experiment only 30% of limestone in the diet.

Substitution of 25-OH-D_3 for cholecalciferol positively affected yielding load and stiffness of bones. Yielding load in chickens fed diet with vitamin D_3 substituted in 90 or 100% by 25-OH-D_3 were higher as compare to chickens fed diet without 25-OH-D_3 ($P \le 0.05$). In the case of stiffness, all levels of vitamin D_3 replacement by 25-OH-D_3 significantly increased value of this parameter. Beneficial effect of 25-OH-D_3 addition to the diet on quality of bones, observed in this experiment, indicated, that hydroxylation of cholecalciferol to 25-OH-D_3 in the liver may be not enough effective for bones development in fast growing young chickens. It was suggested, that in broilers raised in stressful conditions (high density, heat stress, some diseases or immune disorders, etc) – the absorption or liver hydroxylation of vitamin D_3 may be impaired (Yarger et al., 1995). Positive influence of 25-OH-D_3 in the diet on bones quality and prevention of TD was observed among others by Rennie and Whitehead (1996) and Fritts and Waldroup (2003).

Table2. Effect of grit and 25-OH-D_3 on mechanical properties of tibia bones

% of 25-OH-D_3 in whole amount of added vitamin D_3	Ultimate load N			Yielding load N			Stiffness $N \cdot mm^{-1}$		
	% of grit in whole amount of used calcium carbonate								
	0	30	**Mean**	0	30	**Mean**	0	30	**Mean**
0	384	390	**387**	247	247	**247^{a}**	127	136	**131^{a}**
20	394	427	**409**	260	288	**274^{ab}**	140	157	**148^{b}**
40	410	390	**401**	269	270	**269^{ab}**	148	154	**151^{b}**
50	389	429	**409**	269	295	**282^{ab}**	147	155	**151^{b}**
60	410	417	**414**	267	285	**276^{ab}**	150	143	**147^{b}**
80	385	438	**411**	261	324	**292^{b}**	146	160	**153^{b}**
100	386	436	**411**	251	318	**285^{b}**	144	158	**151^{b}**
Mean	**394^{x}**	**418^{y}**		**261^{x}**	**289^{y}**		**143^{x}**	**152^{y}**	
SEM	4.37			4.70			1.90		
Effect of:									
Ca source	**			**			*		
Vitamin D_3	NS			*			*		
Interaction	NS			NS			NS		

$^{x, y}$ – values in the rows with different letters differ significantly ($P \le 0.05$); $^{a, b}$ – values in the columns with different letters differ significantly ($P \le 0.05$); NS – $P > 0.05$; * - $P \le 0.05$; ** - $P \le 0.01$

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