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Performance Evaluation and Bone Characteristics of Growing Cockerel Fed Diets Containing Different Levels of Diatomaceous Earth

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Abstract: The effect of inclusion of different levels of diatomaceous earth (fossil shell flour) on performance and morphology of tibia bone of cockerel was investigated. The experiment comprised 120 six weeks old cockerels, which were randomly alloted to four dietary treatments; control (T1) and three differents levels of inclusion of fossil flour 2% (T2), 4% (T3), 6% (T4). The control birds were fed normal diet. Each diet was replicated 6 times with 5 birds in each replicate in a completely randomised design. Tibiotarsi weight, length and robusticity index, were not significantly ($p<0.05$) affected by supplementation of fossil flour. However, birds fed 6% inclusion of fossil shell had the highest levels of percentage Ca, P and Ash. There was no treatment impact on the average feed intake of the birds, although the average weight gain of birds fed 6% fossil flour was significantly ($p<0.05$) higher throughout the 16-week feeding trial.

Key words: Fossil shell flour · Performance · Tibia

INTRODUCTION

Subtherapeutic use of antibiotics in poultry feeds has become undesirable because of the residuals in meatproducts and development of antibiotic-resistant bacterial populations in humans. In Europe, use of antibiotics as growth-promoting agents for poultry has been banned. Diatomaceous Earth or Fossil Shell Flour (FSF) is so pure that the Food and Drug Administration has given it a "food-grade" designation. The health improvements observed in animals appear to be a result of three primary actions: Eliminating parasites, reduces physiological stress and increases assimilation of nutrients from food; FSF is a rich source of minerals not abundantly available in today's feed crops and FSF may bind to toxic metal build-up and help rid it from the body. As a feed additive for livestock, FSF increases herd appetite and production, stimulates the basic metabolism, increase protein digestion, contains 15 trace minerals which are important to animal diets, absorbs destructive and poisonous sediments in animals. However, FSF can potentially decrease the bulk density and flow rate of grain [1, 2]. These effects on physical properties are largely dose dependent [3].

Normal bone development in birds is influenced by nutritional factors, genetics, gender and the absolute growth rate. Skeletal disorders are more pronounced in fast-growing birds. The skeleton not only provides structural support for the bird but also is an important mineral source for metabolic needs. Bone tissue is complex and composed of inorganic substances such as Ca and P, which provide hardness and strength and organic substances, which give elasticity to bone. A number of invasive (bone ash, breaking strength, weight and bone volume) and noninvasive methods (ultrasound) exist to determine the bone mineralization in poultry [4, 5]. Barnet and Nordin [6] utilized tibiotarsal index as another morphometric method to describe the degree of bone mineralization. Virtama and Telkka [7] showed a significant positive correlation between this method and bone mineral content in humans. Seedor *et al.* [8] similarly used the robusticity index and the bone weight/bone length index to describe bone mineralization. Mutus *et al.* [9], showed that there was no significant difference between the tibiotarsal weight, length and weight/length index and robusticity index of broiler fed dietary supplementation of probiotic.

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The aim of this study was to investigate the effects of a fossil shell flour supplement on the tibial bone characteristics and strength in growing cockerel.

MATERIALS AND METHODS

One hundred and twenty - six weeks old cockerels were used for the study. Thirty birds were assigned to each of the four dietary treatments, which were replicated six times with five birds per replicate in a 16-week feeding trial. The management of the birds was as outlined by Oluyemi and Robert [10].

Four dietary treatments were formulated including the control and different levels of fossil shell flour inclusion (0%, 2%, 4% and 6% of the total diet). The diets were made isonitrogenous (18 % Crude Protein) for growing phase and with the provision for at least the minimum calorie requirement of the chicken as recommended by Oluyemi and Robert [10]. At the begining of the experiment, the birds were weighed and allocated to their respective treatment diets. Records of feed consumption and body weight were taken on weekly basis. Body weight gain and feed conversion ratio were estimated from the data collected.

All the experimental birds were sacrificed by severing the carotid arteries with subsequent exsanguination. The left and right tibia of each bird were removed as drumsticks with flesh intact. The drumsticks were labeled and immersed in boiling water (100 °C) for 10 min. After cooling to room temperature, the drumsticks were defleshed by hand. They were then air-dried for 24 h at room temperature. The tibiotarsal length and bone weight were determined. The bone weight/length index was obtained by dividing the tibia weight by its length [8]. The tibiotarsal and the robusticity indexes are determined using the following formulas, respectively:

robusticity index = bone length / cube root of bone weight [11].

To determine bone ash content, bones were oven-dried at 105°C for 24 h and ashed in a muffle furnace at 600 °C for 6 h according to the procedure of A.O.A.C. [12]. The percentage ash was determined relative to dry weight of the tibia.

Statistical Analysis: All data collected were subjected to analysis of variance of completely randomized design using the SAS [13] package and the means were separated using Duncan multiple range test of the same software. The model used was;

$$Y_{ij} = \mu + T_i + e_{ij}$$

where:

Y_{ij} = Observation, μ = Overall mean,
T_i = Treatments effect e_{ij} = Residual error

RESULTS

There were no significant changes in the average feed intake of the birds fed different inclusions of fossil shell flour. Average feed intake per week of cockerels in the control and 6% fossil shell group were 526.25g and 541.87g respectively and not statistically different. However, average body weight and conversion were significantly affected by the dietary fossil shell flour supplementation (Table 3). Birds on the 6% (Diet 3) fossil shell had better feed conversion rate (5.42) than those on the control diet (5.88).

Tibiotarsi weight, length and robusticity index were not affected by the different fossil shell supplimented diet (Table 4). Birds fed the diets 2 (4%) and 3 (6%) fossil shell supplimented diets had no significantly different tibiotarsal index, whereas birds fed with the control diet had the least value (76.48). Tibia ash, P and Ca concentrations of cockerels fed the fossil shell-supplemented diets were significantly greater than those fed with the control diet. The percentage tibia ash, Ca and P increased significantly as the inclusion of fossil shell increased.

Table 1: Composition of Fossil Shell Flour

Aluminum (Al) %	0.65
Boron (B)	0.0023
Calcium (Ca)	0.40
% CaO (calculated from %Ca)	0.55
Copper (Cu)	0.0019
Iron (Fe)	0.72
Magnesium (Mg)	0.21
%MgO (calculated from %Mg)	0.34
Manganese (Mn)	0.0052
Phosphorus (as P205)	0.037
Potassium (K)	0.16
Sodium (Na)	0.26
Strontium (Sr) ppm	59.9
Sulfate Sulfur (S)	0.062
Titanium (Ti) ppm	420
Vanadium (V)ppm	43.8
Zinc (Zn)	0.0022
Chlorides	0.074% or 740ppm or 0.067% or 670ppm

Source: www.freshwaterorganics.com

Table 2: Gross Composition of Experimental Cockerel Diets

	Dietary Treatments			
Ingredient (%)	(Control) (0% FSF)	T1 (2% FSF)	T2 (4% FSF)	T3 (6% FSF)
Maize	50.00	48.00	48.00	48.00
Palm kernel cake	12.00	12.00	11.00	11.00
Wheat offal	12.00	12.00	11.00	10.00
Fish meal	1.00	1.00	1.00	1.00
Groundnut cake	19.00	19.00	19.00	18.00
Oyster shell	2.50	2.50	2.50	2.50
Bone meal	2.50	2.50	2.50	2.50
Salt	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.20	0.20
Methionine	0.20	0.20	0.20	0.20
Fossil shell flour	0.00	2.00	4.00	6.00
Total	100.00	100.00	100.00	100.00
Calculated Nutrient Composition				
Crude Protein %)	18.40	18.27	17.92	17.30
Metabolisable Energy (kcal/kg)	2732.60	2663.92	2623.47	2578.37
Crude Fibre (%)	4.42	4.38	4.18	4.04

Table 3: Performance Characteristics Of Growing Cockerels Fed Fossil Shell Flour Supplement

	Dietary fossil shell flour inclusion levels				
	Control (0% FSF)	T1 (2% FSF)	T2 (4% FSF)	T3 (6% FSF)	SEM
Average body weight gain/bird/week (g)	89.37^{c}	96.35^{b}	96.25^{b}	100.00^{a}	3.90
Average feed intake/bird/week (g)	526.25	562.50	545.63	541.87	0.30
Average feed conversion ratio	5.88^{a}	5.84^{ab}	5.66^{b}	5.42^{c}	0.02

a,b Means with different superscripts within the same row differ significantly (*P*< 0.05).
SEM = Standard error of means

Table 4: The Effect of Fossil Shell Flour Supplementation on Mineral Content and Bone Strength Measurements of Tibia of Cockerel

	Dietary fossil shell flour inclusion levels				
	Control (0% FSF)	T1 (2% FSF)	T2 (4% FSF)	T3 (6% FSF)	SEM
Weight (g)	10.34	11.48	11.54	11.60	0.31
Lenght (cm)	13.52	14.02	13.78	13.84	0.09
Tibiotarsal(wt/lenght index, mg/mm)	76.48^{b}	81.88^{ab}	83.74^{a}	83.81^{a}	4.94
Robucity	0.135	0.14	0.138	0.138	0.009
Ash (%)	33.78^{c}	39.58^{b}	45.73^{b}	50.47^{a}	1.93
Calcium (%)	20.62^{c}	25.00^{b}	26.20^{b}	30.40^{a}	1.65
Phosphorus (%)	8.79^{c}	12.12^{b}	13.32^{b}	15.93^{a}	1.02

a,b Means with different superscripts within the same row differ significantly (*P*< 0.05).
SEM = Standard error of means

DISCUSSION

The better performance characteristics observed in cockerel fed 6% fosssil shell flour could be attributed to the increase in fossil shell which resulted in elimination of physiological stress and better feed assimilation. The bone weight/bone length index is a simple index of bone density. The higher the index, the denser is the bone [14]. On the contrary, low robusticity index indicates a strong bone structure [11]. Also the high value of the tibiotarsal index shows the high mineralization level of the bone [15]. The tibiotarsal index of cockerel fed fossil shell was higher compared with those that were fed control diet (Table 4). These results suggest that the inclusion of fossil flour increased the degree of mineralization and development of bone. Although [9], showed that there was no significant difference between the tibiotarsal weight, length and weight/length index and robusticity index, of broiler fed dietary supplementation of probiotic, this study however revealed a contrary result with respect to the weight/lenght index this could probably be due to the increase level of fossil shell flour in the diets or probably due to the different breed of poultry used (Cockerel) which takes a longer time to mature. Increased bone ash might suggest an improvement in bone mineralization.

CONCLUSION

The present study demonstrated that bone properties of the tibia of cockerel are affected when fed different levels of fossil flour-supplemented diets. However, there is a need for further studies to determine the mode of action of fossil flour on bone mineralization.

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