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Effect of natural zeolite (clinoptilolite) on the performance and litter quality of broiler chickens

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Abstract: This work was conducted to study the effect of dietary supplementation with natural zeolite on the performance and litter quality of broilers. In a randomized complete block experimental design, 480-day-old Cobb-500 broilers were divided into 4 treatments with 4 replicates each and 30 chicks per replicate. The dietary treatments consisted of a control wheat–corn–soybean meal diet (C) and 3 others contained 1.0%, 2.0%, or 3.0% zeolite for Z_1, Z_2, and Z_3 treatments, respectively. Feed intake was significantly ($P < 0.05$) higher in Z_1, Z_2, and Z_3 treatments as compared to the control diet. Compared to the control, diets containing 2% and 3% of zeolite showed a significant ($P < 0.05$) increase in body weight gain and feed conversion ratio for the total period. The dietary addition of zeolite significantly ($P < 0.05$) decreased the organic content in litter samples throughout the experimental period. The results of this study showed that the dietary addition of natural zeolite at inclusion rates of 2% and 3% had a positive effect on feed conversion ratio, body weight gain, and litter quality of broilers.

Key words: Broilers, zeolite, performance, litter quality

1. Introduction

Zeolites have the ability to gain and lose water reversibly and to exchange constituent ionic cations without major changes of structure (1,2). The zeolitic material used in this experiment was obtained from the Paleogene zeolite-rich tuffs of the Evros area, Thrace, northeastern Greece. It contained almost 88% calcium-rich clinoptilolite (3,4). Clinoptilolite is a naturally occurring zeolite that belongs to a family of crystalline aluminosilicate minerals. They have a 3-dimensional, porous structure that is responsible for specific cation exchange capacity (5). Chemical microanalysis of the clinoptilolite was determined by Karamanlis et al. (6).

There has been recent interest in the use of natural zeolites as a feed additive (6–9) and as a means of reducing odor and ammonia emissions from broiler houses (10). The addition of zeolite or an organic acid-plus-zeolite combination to the diet, with microbial phytase containing low and adequate levels of P, had positive effects on the performance of broilers (11). However, there is inadequate new information on the impact of clinoptilolite on the performance and litter quality of broilers when it is used as a supplement in the diet.

The aim of this study, therefore, was to investigate the effects of dietary supplementation with natural zeolite (clinoptilolite) on the performance of broilers as well as in the quality of excreta/litter in broiler houses.

2. Materials and methods

2.1. Animals and housing

In this experiment, 480 Cobb-500 broilers of 1 day old and uniform weight were randomly allocated into 4 treatments, with 4 replicate groups per treatment and 30 chicks per replicate. The size of all pens was 2.5 × 2.0 m; therefore, each bird had an area of about 0.16 m^2. Each pen was equipped with 3 feed troughs and 3 adjustable drinkers for food and water provision, respectively. The bedding was rice hulls. The temperature was maintained at 32 °C during the first week and then gradually reduced by 3 °C per week until it reached 18 °C; this temperature was maintained until the end of the experiment. Relative humidity of the room was 40%–60% and artificial lighting was set to provide 23 h of light and 1 h of darkness daily.

2.2. Experimental diets

Dietary treatments consisted of a control wheat–corn–soybean meal diet . Three other treatments contained

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1.0%, 2.0%, or 3.0% zeolite for Z_1, Z_2, and Z_3 treatments, respectively, according to randomized complete block experimental design. A 2-phase feeding program was performed based on National Research Council (12) recommendations. The starter diet was used from the 1st to 21st day, and the grower was used from the 22nd to 42nd day. Feed and water were given ad libitum. Table 1 shows the composition of the diets. The diets for the starting phase were calculated to contain 22.2% crude protein (CP) and 3150 kcal metabolizable energy (ME) kg^{-1} of diet. They also contained 21.0% CP and 3100 kcal ME kg^{-1} of diet for the growing phase. Diets formulated were isocaloric, isonitrogenous, and balanced for methionine, lysine, vitamins, and mineral content.

2.3. Measurements

The body weight gain of all chicks from all treatments was recorded weekly. Feed refusals of each treatment were also recorded in the same periods. Based on feed refusals, the average feed consumption as well as feed conversion ratio was calculated for each treatment. Litter sampling also took place on the 20th, 30th, and 40th days, respectively. Litter quality was assessed in a series of samples that were obtained from 3 different points located along the bevel in each pen. Each sample was transferred to the laboratory as soon as possible for analyses. Following the American Public Health Association standard methods (13), moisture, organic solids, and the total Kjeldahl nitrogen content were determined for each individual sample. Moisture content (%) of samples was determined by drying samples to a constant weight at 105 °C. Organic content (% of total solids) was determined by sample combustion at 550 °C after drying them to a constant weight at 105 °C. Total levels of Kjeldahl nitrogen were determined by the macro-Kjeldahl method.

Table 1. Composition of experimental broiler diets for the starting (0–3 weeks) and finishing phase (3–6 weeks).

Ingredients (g/kg)	Starting phase				Finishing phase			
	C[1]	Z_1[1]	Z_2[1]	Z_3[1]	C[1]	Z_1[1]	Z_2[1]	Z_3[1]
Wheat	332.6	321.6	310.6	299.6	640.0	617.0	594.2	571.0
Corn	200.0	192.0	184.0	176.0				
Soybean meal (44%)	330.0	334.0	338.0	342.0	274.0	278.0	282.0	286.0
Plant oil	39.1	39.1	39.1	39.1	26.0	29.0	32.0	35.0
Corn gluten meal (60%)	26.9	25.0	23.1	21.2				
Skimmed milk powder	12.5	12.5	12.5	12.5				
Soybean oil	10.0	16.9	23.8	30.7	22.0	28.0	34.0	40.0
Limestone	15.4	15.4	15.4	15.4				
Zeolite	-	10.0	20.0	30.0	-	10.0	20.0	30.0
Dicalcium phosphate	11.9	11.9	11.9	11.9	10.5	12.0	12.0	12.0
Calcium carbonate	-	-	-	-	11.0	11.0	11.0	11.0
Vitamins + minerals	-	-	-	-	2.5	2.5	2.5	2.5
Biolysine (65%)	5.0	5.0	5.0	5.0	2.5	2.5	2.5	2.5
Wet methionine	1.4	1.4	1.4	1.4				
Methionine (99%)	1.1	1.1	1.1	1.1	2.5	2.5	2.5	2.5
Threonine	0.5	0.5	0.5	0.5	2.0	2.0	2.0	2.0
Antioxidants	6.0	6.0	6.0	6.0				
Salt	2.6	2.6	2.6	2.6	2.5	2.3	2.3	2.2
Soda	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5
Arabinoxylanase + phytase	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0
Anticoccidials	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Metabolizable energy (kcal/kg)*	3105	3090	3085	3110	3150	3145	3144	3140
Crude protein*	22.2	22.3	22.1	22.0	21.0	21.1	21.2	20.8

*: NRC tables (12).

[1]: C: control; Z_1, Z_2, and Z_3: treatments containing 1%, 2%, and 3% natural zeolite, respectively.

Table 2. Effect of zeolite on daily feed intake[1] (g), body weight gain[2] (g), and feed conversion ratio[3] (kg of feed/kg of body weight gain).

Treatments	Week						Total period
	1	2	3	4	5	6	
Feed intake (g)							
Control (C)	18.0	51.3^{a}	88.8	116.3	148.0^{a}	186.4^{ab}	101.5
Zeolite 1%	17.0	62.7^{b}	87.0	105.6	168.8^{b}	199.6^{c}	106.8
Zeolite 2%	16.8	50.6^{a}	86.5	116.9	170.0^{b}	181.4^{a}	103.7
Zeolite 3%	15.9	51.7^{a}	84.0	110.1	171.6^{b}	191.4^{b}	104.1
SE	2.00	4.45	5.03	6.84	8.42	8.63	4.07
P	NS	*	NS	NS	*	*	NS
Average body weight gain (g)							
Control (C)	14.3^{b}	40.0^{a}	52.9^{ab}	60.6^{bc}	73.8^{a}	79.1^{a}	53.4^{a}
Zeolite 1%	12.9^{ab}	49.0^{b}	50.0^{a}	55.0^{a}	86.6^{b}	92.0^{b}	57.6^{ab}
Zeolite 2%	12.1^{a}	44.0^{ab}	57.1^{b}	62.9^{c}	89.5^{b}	94.5^{b}	60.0^{b}
Zeolite 3%	12.3^{a}	47.0^{b}	57.1^{b}	58.6^{ab}	88.0^{b}	95.7^{b}	59.8^{b}
SE	1.45	3.42	3.84	3.87	4.45	4.93	3.96
P	*	*	*	*	*	*	*
Feed conversion ratio (kg of feed/kg of body weight gain)							
Control (C)	1.26^{a}	1.28^{a}	1.68^{a}	1.92^{a}	2.00^{a}	2.36^{a}	1.75^{a}
Zeolite 1%	1.32^{bc}	1.28^{a}	1.74^{a}	1.92^{a}	1.95^{b}	2.17^{b}	1.73^{a}
Zeolite 2%	1.38^{c}	1.15^{b}	1.51^{b}	1.86^{b}	1.90^{c}	1.92^{c}	1.62^{b}
Zeolite 3%	1.30^{ab}	1.10^{b}	1.47^{b}	1.88^{b}	1.95^{b}	2.00^{c}	1.61^{b}
SE	0.04	0.05	0.04	0.02	0.03	0.05	0.03
P	*	*	*	*	*	*	*

[1, 2, 3]: Means and standard errors (SE).
[a, b, c]: Means in the same column sharing a different superscript are significantly different at *P < 0.05. NS: not significant.

2.4. Statistical analysis

Data were statistically analyzed according to the one-way ANOVA procedure (14) using SPSS 16. Duncan's (15) and Dunnett's (16) multiple range test procedures were used to identify significant differences between the mean values for each treatment. Differences among means for $P < 0.05$ were considered satisfactory and adequate.

3. Results

Table 2 shows the effects of different levels of zeolite on feed intake, body weight gain, and feed conversion ratio. Feed intake was significantly ($P < 0.05$) higher in the 1% zeolite group during the 2nd, 5th, and 6th weeks; in the 2% zeolite group during the 5th week; and in the 3% zeolite group during the 5th week, as compared to the control diet. During the 2nd and 6th weeks, significant differences ($P < 0.05$) in feed intake were also detected among the 3 levels of zeolite.

There were no significant effects of zeolite addition on feed intake in the 1st, 3rd, 4th, and total periods. Diets containing 3% zeolite significantly ($P < 0.05$) increased average body weight gain (BWG) during the 2nd, 5th, and 6th weeks and for the total period. Meanwhile, 2.0% zeolite significantly ($P < 0.05$) increased average BWG in the 5th and 6th weeks and for the total period compared to the control diet.

The addition of 1% zeolite significantly ($P < 0.05$) increased average BWG during the 2nd, 5th, and 6th weeks when compared to the control diet. The feed conversion ratio (FCR) significantly improved ($P < 0.05$) in diets with 2% and 3% zeolite at the 2nd, 3rd, 4th, 5th, and 6th weeks and for the total period compared to the control diet. The addition of 1% zeolite at the 5th and 6th weeks significantly ($P < 0.05$) improved FCR as compared to the control diet.

Data for the litter quality that were determined in litter samples obtained from each of the pens are presented in Table 3. As expected, there was an increase ($P < 0.05$) in moisture content in litter samples for all treatment groups by time (average values were 24.65%, 32.62%, and 39.99% for days 20, 30, and 40 respectively) due to the continuous

Table 3. Litter quality parameters[1].

Parameters	Treatments[2]						
	Day	C	Z_1	Z_2	Z_3	SE	P
Moisture content (%)	20th	30.2[a]	25.6[b]	22.3[b]	20.5[b]	3.51	*
	30th	42.9[a]	35.1[b]	27.5[c]	25.0[c]	4.43	*
	40th	48.9[a]	40.7[b]	34.8[c]	35.5[c]	4.24	*
Total solid content (%)	20th	90.2	88.9	89.0	87.8	2.63	NS
	30th	82.0[a]	82.7[a]	80.1[ab]	78.1[b]	2.02	*
	40th	78.6[a]	77.6[ab]	75.7[b]	75.4[b]	1.94	*
Nitrogen content (g/kg of litter)	20th	14.1	14.3	14.8	14.9	0.75	NS
	30th	18.5	18.8	19.1	19.5	0.64	NS
	40th	20.2	21.4	22.0	22.2	0.45	NS

[1]: Means and standard errors (SE).
[2]: C: control; Z_1, Z_2, and Z_3: treatments containing 1%, 2%, and 3% natural zeolite, respectively.
[a, b, c]: Means in the same row sharing a different superscript are significantly different at *P < 0.05. NS: not significant.

accumulation of broilers excreta. This increase was significant (P < 0.05) for the groups of Z_1, Z_2, and Z_3 in comparison to the control. The incorporation of natural zeolite in broiler diets decreased the organic content in litter samples throughout the experimental period. The lowest organic content was recorded in groups Z_2 and Z_3 (40th day), where zeolite was added to feed at levels of 2% and 3%, respectively. Furthermore, significant (P < 0.05) differences were recorded between treatment group Z_3 in comparison to the control group at days 30 and 40. Total Kjeldahl nitrogen concentration showed a tendency to increase by time (average values of 11.53, 18.97, and 21.45 g/kg).

4. Discussion

The aforementioned findings concerning the feed intake of broilers are in general agreement with findings of other research (17–19), but not with those of Acosta et al. (20), who reported that the addition of 1% zeolite in broiler diets decreased feed intake. Results concerning BWG of broilers are in agreement with other reports (7,18,19,21–23). Although Altiner et al. (24) found that the addition of natural zeolite in the diet had no significant effect on BWG, it is possible to relate the existing differences in different experimental results to silicate minerals used in broiler diets.

These differences may be due to the structure of the minerals and to their metal oxide contents. Pasha et al. (23) and Katouli et al. (19) showed that natural zeolite improved FCR. Oguz and Kurtoglu (25), Pasha et al. (23), and Shi et al. (26) reported an improved FCR by adding silicate minerals to diets. However, Cabuk et al. (17) reported that the supplementation of zeolite to the diet had no effect on the FCR.

Unfortunately, there is not adequate information concerning the effect of natural zeolite's dietary supplementation on the litter quality of poultry housing. Although excreta/litter moisture and quality are related with the health, performance, and welfare of broilers, they may be the source of environmental and management problems in the commercial poultry industry (27,28).

The results of this study showed that the use of natural zeolite as a feed additive had a beneficial effect on broilers' performance and led to the improvement of their litter quality. Hence, it is concluded that the use of alternative management strategies can include natural zeolites. However, other parameters, such as the type of the natural zeolite or its inclusion rate, need further investigation.

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