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Effect of Different Levels of Kaolin, Bentonite and Zeolite on Broilers Performance

M. Safaei Katouli, F. Boldaji, B. Dastar and S. Hassani
Department of Animal Science,
Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

Abstract: An experiment was conducted to study the effects of different levels of kaolin, bentonite and zeolite on broiler performance in 6 weeks. Four hundred and forty eight day-old broilers of male Ross 308 strain were allocated to 7 treatments with four replications and 16 broilers in each. The experiment was carried out in a completely randomized design. Treatments were control and 1.5, 3% of kaolin, bentonite and zeolite. Treatments with 3% zeolite and bentonite was significantly ($p<0.05$) increased weight gain during the 1st and 6th weeks, 1.5% kaolin and zeolite, significantly ($p<0.05$) increased weight gain in 5th and 6th weeks compared to the control, respectively. Treatments 1.5% bentonite in 4th and 5th weeks and 1.5% zeolite and 3% bentonite in 5th week was significantly ($p<0.05$) increased feed intake compared to the control. Feed conversion ratio in diets with 3% kaolin in the 1st and 2nd weeks and 3% zeolite in the 1st week was significantly ($p<0.05$) improved compared to the control. There was no significant ($p>0.05$) differences in internal organs and fecal pH between trial groups and control. Fecal moisture in treatments with 1.5% kaolin, 3% bentonite and zeolite was significantly ($p<0.05$) different from control. Growth rate in treats containing 3% kaolin at 0-3 week and 1.5% zeolite, 1.5% kaolin and 3% kaolin, bentonite and zeolite at 0-6 week was more than control ($p<0.05$). The results demonstrated that adding silicate minerals in diet, improve performance of broiler chickens.

Key words: Kaolin, bentonite, zeolite, performance, broiler

INTRODUCTION

Silicates cover about 90% of earth's minerals. Kaolin and bentonite belong to group of silicates with the name of phillosilicates. Phillosilicates are classified into the main group according to the type of the layers, interlayer content, charge of the layers and chemical formulas. Kaolin is a plastic raw material, particularly consisting of the clay mineral kaolinite. The chemical formula is $Al_2O_3.2SiO_2.2H_2O$. Structure kaolinite allowed easily adsorbs water and forms a plastic, paste-like substance (Trckova *et al*., 2004). Bentonites are clays with strong colloidal properties that absorb water rapidly, which results in swelling and a manifold increase in volume, giving rise to a thixotropic gelatinous substance (Pasha *et al*., 2008). Bentonite is actually a mixture of minerals from montmorilonite group with high ion exchange capacity which binds with deferent cations (Huntington *et al*., 1977; Walz *et al*., 1998).

Zeolites are crystalline, hydrated aluminosilicates of alkali and alkaline earth cations having three dimensional structures. Among many properties attributed to zeolites, two most characteristics that relates to their effectiveness in animal nutrition are their ability to lose and gain water reversibly and being capable of exchanging selectively a variety of cations in their structure without much major changes of structure (Mumpton and Fishman, 1977; Shariatmadari, 2008). Some studies show that the use of silicate minerals in broiler chickens diet would improve their weight gain (Prvulovic *et al*., 2008; Salari *et al*., 2006; Tauqir *et al*., 2001). Various researches (Elliot and Edwards, 1991; Pasha *et al*., 2008; Hesham *et al*., 2004) show that the use of these minerals will cause decrease in the feed conversion ratio. One of the benefits of using silicate minerals in the diet is improvement the quality of broiler litter (Cabuk *et al*., 2004).

Therefore, the present study was conducted to further evaluate the effects of dietary kaolin, bentonite and zeolite on broiler body weight gain, feed intake, feed conversion ratio, internal organs, growth rate, fecal moisture and pH.

MATERIALS AND METHODS

The experiment was carried out in Animal Research Station of Gorgan University of Agricultural Sciences and Natural Resources in Golstan province, Iran during December 2008 and April 2009. Four hundred forty eight day-old male broiler chicks of uniform weight (Ross 308) randomly divided into 7 treatments with 4 replicate groups

Corresponding Author: M. Safaei Katouli, Department of Animal Science,
Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran Tel: +989112778689

Table 1: Composition of experimental diets for the starter phase (%)

Feed ingredients	Control	1	2	3	4	5	6
Corn	58.73	55.62	52.5	55.62	52.5	55.62	52.5
Soybean meal	36.03	36.63	37.23	36.63	37.23	36.63	37.23
Soybean oil	1.43	2.44	3.46	2.44	3.46	2.44	3.46
Dicalcium phosphate	1.41	1.41	1.41	1.41	1.41	1.41	1.41
Limestone	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Salt	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Premix*	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DL-Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
salinomycine	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vit E	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Kaolin	-	1.5	3	-	-	-	-
Bentonite	-	-	-	1.5	3	-	-
Zeolite	-	-	-	-	-	1.5	3
Nutrient composition							
ME	2900	2900	2900	2900	2900	2900	2900
CP	20.85	20.85	20.85	20.85	20.85	20.85	20.85

*Premix contained 50% vitamin premix and 50% mineral premix. Each kg of vitamin premix contained: Vitamin A, 3,500,000 IU; Vitamin D3, 1,000,000 IU; Vitamin E, 9000 IU; Vitamin K3, 1000 mg; Vitamin B1, 900 mg; Vitamin B2, 3,300 mg; Vitamin B3, 5,000 mg; Vitamin B5, 15,000 mg; Vitamin B6, 150 mg; Vitamin B9, 500 mg; Vitamin B12, 7.5 mg; Biotin, 500 mg; Choline chloride, 250,000 mg and each kg of mineral premix contained: Mn, 50,000 mg; Fe, 25,000 mg; Zn, 50,000 mg; Cu, 5,000 mg; I, 500 mg, Se, 100 mg

Table 2: Composition of experimental diets for the grower phase (%)

Feed ingredients	Control	1	2	3	4	5	6
Corn	64.81	61.70	58.58	61.70	58.58	61.70	58.58
Soybean meal	30.09	30.69	31.30	30.69	31.30	30.69	31.30
Soybean oil	1.75	2.76	3.77	2.76	3.77	2.76	3.77
Dicalcium phosphate	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Limestone	1.34	1.34	1.34	1.34	1.34	1.34	1.34
Salt	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Premix*	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DL-Methionine	0.07	0.07	0.07	0.07	0.07	0.07	0.07
salinomycine	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vit E	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Kaolin	-	1.5	3	-	-	-	-
Bentonite	-	-	-	1.5	3	-	-
Zeolite	-	-	-	-	-	1.5	3
Nutrient composition							
ME	3000	3000	3000	3000	3000	3000	3000
CP	18.75	18.75	18.75	18.75	18.75	18.75	18.75

*Premix contained 50% vitamin premix and 50% mineral premix. Each kg of vitamin premix contained: Vitamin A, 3,500,000 IU; Vitamin D3, 1,000,000 IU; Vitamin E, 9000 IU; Vitamin K3, 1000 mg; Vitamin B1, 900 mg; Vitamin B2, 3,300 mg; Vitamin B3, 5,000 mg; Vitamin B5, 15,000 mg; Vitamin B6, 150 mg; Vitamin B9, 500 mg; Vitamin B12, 7.5 mg; biotin, 500 mg; choline chloride, 250,000 mg and each kg of mineral premix contained: Mn, 50,000 mg; Fe, 25,000 mg; Zn, 50,000 mg; Cu, 5,000 mg; I, 500 mg, Se, 100 mg

per treatment and 16 chicks per replicate. The size of all pens was 1.5×1.5 m; therefore, each bird had about 0.14 m^2 spaces. The temperature was maintained at 32°C during the 1st week and then was reduced by 3°C per week until 18°C was reached and this temperature was maintained until the end of the experiment. Relative humidity of the room was about 60-70% and artificial lighting was set to provide 24 h of light daily. Dietary treatments consisted of a control corn-soybean meal diet and six other treatments contained 1.5 or 3% of kaolin, bentonite and zeolite for each treatment a 2-phase feeding program was utilized based on NRC (1994) recommendation. The starter diet was fed from 1 to 21 day and the grower from 22 to 42 day. Feed and water were given *ad libitum*. Table 1 and 2 show the composition of the diets. The diets of starter phase calculated to contain 20.85% CP and 2900 kcal of ME per kg of diet. They also contained 18.75% CP and 3000 kcal of ME kg^{-1} of diet for the grower phase. Diets were isonitrogenous and isocaloric and contain the suitable levels of methionine, lysine, vitamins and minerals. Body weight gain, feed intake of all chicks from all pens was recorded weekly. Daily chick mortality were weighed, recorded and added to the total pen live body weight for the calculation of feed conversion ratio during each week. At the 42 days of age, 2 birds from each replicate weighing average of pen weight were selected and body weights were determined, slaughtered and eviscerated in order to determine, liver, heart, spleen, bursa as a percentage of live body weight.

Feces were collected for moisture and pH analysis at 40 days of experiment. The pH of fecal content was determined using a pH meter (Inolab model WTW-720 made in Germany) and moisture content of fecal material was determined according to the method as described in AOAC (2005). Values of growth rate of treatments were measured by using the formula (Bernacki *et al*., 2008).

$$T_m = \frac{(m_k - m_p)}{0.5\,(m_k + m_p)} \times 100$$

Where:
m_k = Final body weight
m_p = Initial body weight

The data were analyzed using the General Linear Models (GLM) procedure of SAS (2003). The treatments means were compared using Duncan's multiple range tests (Duncan, 1955) at 5% probability level.

RESULTS AND DISCUSSION

Table 3 shows the effects of experimental treatments on the feed intake. Feed intake was significantly ($p<0.05$) higher in 1.5% bentonite in 4th and 5th weeks and 1.5% zeolite, 3% bentonite in 5 week compare to the control. Also in 4th week significant differences were found between two levels of bentonite (1.5 and 3%) in feed intake ($p<0.05$). Salari *et al*. (2006) reported that chickens fed diets containing 1, 2% bentonite consume more feed ($p<0.05$). There were no significant effects of dietary treatments on feed intake at 1st, 2nd, 3rd and 6th weeks. These finding are in agreement with others (Cabuk *et al*.,

Table 3: Effect of kaolin, bentonite and zeolite on the average of weekly feed intake (g)

	Week					
Treatments	1	2	3	4	5	6
Control	117.89	345.16	607.81	799.53^{ab}	1016.16^{c}	1232.05
Kaolin (1.5%)	119.53	339.45	624.53	772.50^{ab}	1075.09^{abc}	1297.68
Kaolin (3%)	120.00	334.77	611.64	750.86^{b}	1023.06^{bc}	1266.41
Bentonite (1.5%)	119.69	338.28	570.63	689.42^{c}	1147.19^{b}	1228.81
Bentonite (3%)	123.52	359.61	580.62	827.67^{a}	1167.23^{a}	1332.88
Zeolite (1.5%)	117.42	356.88	616.41	814.87^{ab}	1164.39^{a}	1285.93
Zeolite (3%)	122.11	338.91	591.80	778.44^{ab}	1080.09^{abc}	1319.82
SE	4.51	7.49	18.14	20.16	39.48	32.19

Means within columns with no common superscripts are significantly different ($p<0.05$)

Table 4: Effect of kaolin, bentonite and zeolite on the average of weekly body weight gain (g)

	Week					
Treatments	1	2	3	4	5	6
Control	82.50^{c}	206.02	339.84^{ab}	393.59	504.38^{b}	540.80^{c}
Kaolin (1.5%)	86.17^{abc}	213.20	360.94^{a}	401.25	518.57^{ab}	604.38^{ab}
Kaolin (3%)	90.94^{abc}	221.33	358.13^{ab}	401.95	524.25^{ab}	601.44^{abc}
Bentonite (1.5%)	83.28^{bc}	210.70	333.13^{ab}	381.71	517.90^{ab}	548.08^{bc}
Bentonite (3%)	92.27^{ab}	217.66	330.07^{b}	389.01	531.09^{ab}	622.06^{a}
Zeolite (1.5%)	88.36^{abc}	213.44	344.61^{ab}	418.53	566.72^{a}	574.17^{abc}
Zeolite (3%)	92.97^{a}	217.66	330.07^{ab}	389.01	531.09^{ab}	622.06^{ab}
SE	2.93	6.08	8.68	18.19	16.39	19.37

Means within columns with no common superscripts are significantly different ($p<0.05$)

Table 5: Effect of kaolin, bentonite and zeolite on the average of weekly feed conversion ratio (%)

	Week					
Treatments	1	2	3	4	5	6
Control	1.43^{ab}	1.68^{a}	1.79	2.04^{ab}	2.01^{ab}	2.28
Kaolin (1.5%)	1.39^{abc}	1.60^{ab}	1.73	1.94^{ab}	2.08^{ab}	2.15
Kaolin (3%)	1.32^{c}	1.51^{b}	1.71	1.88^{b}	1.95^{b}	2.11
Bentonite (1.5%)	1.44^{a}	1.61^{ab}	1.71	1.83^{b}	2.22^{a}	2.25
Bentonite (3%)	1.34^{bc}	1.65^{a}	1.76	2.14^{a}	2.20^{a}	2.14
Zeolite (1.5%)	1.33^{bc}	1.68^{a}	1.79	1.95^{ab}	2.06^{ab}	2.25
Zeolite (3%)	1.31^{c}	1.59^{ab}	1.69	1.91^{ab}	1.98^{ab}	2.19
SE	0.03	0.03	0.04	0.08	0.07	0.06

Means within columns with no common superscripts are significantly different ($p<0.05$)

2004; Grosicki *et al*., 2004). Acosta *et al*. (2005) reported the addition of 1% zeolite in diet decrease feed intake.

Diets consisted of 3% zeolite and bentonite ($p<0.05$) increased weight gain during the 1st and 6th weeks, 1.5% kaolin and zeolite significantly ($p<0.05$) increased weight gain in 5th and 6th weeks compared to the control, respectively. In 3rd week significant differences were found in 1.5% kaolin compared with 3% bentonite ($p<0.05$) (Table 4). This result was in agreement with other reports (Tauqir *et al*., 2001; Grosicki *et al*., 2004; Salari *et al*., 2006; Pasha *et al*., 2008). But Elliot and Edwards (1991) and Altiner *et al*. (2009) found that addition natural zeolite to the diet had no effect on body weight ($p>0.05$). It is possible to relate the existing differences in different experimental results, on using silicate minerals in broiler diets, maybe due to the structure of the mineral and the metal oxide content. So, good processing to reduce metal oxide content, as much as possible, will result in better outputs.

Effects of the dietary treatments on feed conversion ratio are shown in (Table 5). Feed conversion ratio in diet with 3% kaolin in the 1st and 2nd weeks and 3% zeolite in the 1st week significantly ($p<0.05$) improved compared to the control. Feed conversion ratio in 3% bentonite treatment at 4th week increased significantly ($p<0.05$) compared to 3% kaolin and 1.5% bentonite treatments. Also in 5th week two levels bentonite (1.5, 3%) showed higher feed conversion ratio against 3% kaolin. Elliot and Edwards (1991) and Pasha *et al*. (2008) showed that feeding of natural zeolite and bentonite improved the feed conversion ratio. Ledoux *et al*. (1999), Oguz and kurtoglu (2000), Rosa *et al*. (2001), Pasha *et al*. (2007) and Shi *et al*. (2009) reported feed conversion ratio improved by adding silicate minerals to AF-containing diets. Whereas Cabuk *et al*. (2004) reported that the supplementation of zeolite to the diet had no effect on feed conversion ratio.

The effects of dietary treatments on the Growth rate, fecal moisture and pH are presented in Table 6. The growth rate could be considered as an important characteristic in effects of silicate mineral in broiler performance. In this research, growth rate value at 0-3 week in 3% kaolin and 0-6 week at 1.5% kaolin, zeolite and 3% kaolin, bentonite, zeolite was more than control ($p<0.05$). There were no significant differences in growth rate at 3-6 week of age among treatments ($p<0.05$).

Fecal moisture in treats with 1.5% kaolin and 3% bentonite and zeolite significantly ($p<0.05$) decreased compared to control. But there were no significant ($p>0.05$) differences in fecal pH among treatments. Miles

Table 6: Effect of kaolin, bentonite and zeolite on growth rate value, fecal moisture (%) and fecal pH

	Growth rate (week)			Fecal (40 days)	
Treatments	0-3	3-6	0-6	Moisture	pH
Control	176.05^{b}	78.30	192.40^{c}	79.14^{a}	7.05
Kaolin (1.5%)	177.10^{ab}	79.16	192.80^{ab}	73.07^{c}	6.59
Kaolin (3%)	177.47^{a}	77.88	192.84^{a}	75.28^{abc}	6.44
Bentonite (1.5%)	175.97^{b}	79.09	192.43^{bc}	75.64^{ab}	6.50
Bentonite (3%)	176.46^{ab}	82.61	192.79^{ab}	73.54^{c}	6.39
Zeolite (1.5%)	176.66^{ab}	82.71	192.87^{a}	78.53^{abc}	6.69
Zeolite (3%)	176.98^{ab}	81.55	192.90^{a}	73.01^{bc}	6.60
SE	0.42	2.32	0.13	0.71	0.20

Means within columns with no common superscripts are significantly different ($p<0.05$)

Table 7: Effect of kaolin, bentonite and zeolite on internal organs as percent of LBW*

Treatments	Liver	Spleen	Heart	Bursa
Control	2.74	0.12	0.70	0.12
Kaolin (1.5%)	2.64	0.12	0.62	0.11
Kaolin (3%)	2.60	0.11	0.60	0.15
Bentonite (1.5%)	2.63	0.12	0.60	0.09
Bentonite (3%)	2.60	0.12	0.63	0.12
Zeolite (1.5%)	2.67	0.13	0.64	0.12
Zeolite (3%)	2.43	0.15	0.64	0.14
SE	0.10	0.01	0.03	0.02

*LBW= Live body weight

and Henry (2007) reported fecal moisture decreased linearly ($p<0.001$) in response to increase in hydrate sodium calcium aluminosilicates in diet.

There were no significant ($p<0.05$) differences in internal organs between trial groups and control (Table 7). These results are in agreement with (Santin *et al*., 2002; Grosicki *et al*., 2004; Hesham *et al*., 2004; Shi *et al*., 2009). Prvulovic *et al*. (2008) reported that spleen weight was significantly higher ($p<0.05$) in the 5% zeolite treatment whereas the weight of the other measured organs were not affected by the dietary treatment.

CONCLUSION

The results of this study showed that using silicate minerals in diet had no adverse effect on broiler performance and internal organs. Also, it improved growth rate, body weight gain and feed conversion ratio and decreased fecal moisture.

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