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RESEARCH ARTICLE

Effect of Different Sodium Bentonite Levels on Performance, Carcass Traits and Passage Rate of Broilers

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ABSTRACT

The aim of this study was to investigate effects of different sodium bentonite (SB) levels on performance, carcass characteristics and passage rate of broilers. Two hundred eighty eight day-old Ross strain mix broilers were allocated to 6 experimental diets with 4 replications in a completely randomized design. Treatments levels of sodium bentonite were 0.00, 0.75, 1.50, 2.25, 3.00 and 3.75%. Broilers fed SB containing diets consumed more feeds ($P<0.05$) and showed better weight gain ($P>0.05$) with no difference across treatments containing SB. The diet with 3.75% SB had the best FCR. Relative weight of liver decreased as percentage of SB increased in diet while control group had highest relative weight of breast ($P<0.05$). Supplementation of diets by SB increased retention time and decreased gastrointestinal passage rate. The use of SB in broiler diets had no adverse effects on performance; addition SB to broiler diets had beneficial effects on performance, carcass characteristics and passage rate and resulted in improved efficiency of production.

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INTRODUCTION

Bentonite as a feed additive has been used successfully in poultry feeds without any harmful effects (Prvulovic *et al*., 2008; Safaeikatouli *et al*., 2010). The use of clay supplements in animal and poultry feed manufacturing is not new. Phyllosilicate clays are crystalline, hydrate aluminosilicates that contain alkali and alkaline earth cations, and have a layered structure. Phyllosilicates vary in their composition from one phyllosilicate to another, depending mainly on the interchangeable ions that may be contained within their structure (Phillips, *et al.,* 1994). Bentonite is a clay mineral with strong colloidal properties that absorb water rapidly and results in swelling and increase in volume. For many years, bentonite has been used as a binder in the feed industry and pharmaceutical preparations (Grosicki, 2008). Aflatoxins severely inhibited the immune system of the birds and reduced the titers of both Newcastle and infectious bursal disease vaccines. Sodium bentonite was able to counteract this effect (Bailey *et al*., 2006; Kermanshahi *et al*., 2009; Shi *et al*., 2009); addition of sodium bentonite was significantly effective in ameliorating the negative effect of aflatoxins on the percentage and mean of phagocytosis (Moghadam *et al.*, 2008).

Bentonite slowed down feed passage rate for better utilization of feed nutrients (Damiri *et al.,* 2010). Bentonite is tri-layered aluminium silicate having sodium or calcium as its exchangeable cations. Sodium form is the best and mineral hydration results in a five-fold increase in weight. During this change, aluminum silicate layers become separated and water is attracted to their ionic surfaces creating a 12 to 15 fold increase in volume. The ingredients of Bentonite are SiO_2, 66%; Al_2O_3, 16.3%; H_2O (Crystal), 60%; Fe_2O_3, 3.3%; Na_2O, 2.6%; CaO, 1.8%; MgO, 1.5%; K_2O, 0.48%; TiO_2, 0.12% (Salari *et al*., 2006; Sallary *et al.,* 2008). Several studies showed that poultry feed supplemented with Bentonite can improve growth performance (Damiri *et al.,* 2010).

The special properties of Bentonite such as hydration, swelling, water adsorption and viscosity made it a valuable material for wide range of applications in industrial and farming systems (Miazzo, *et al*., 2005). Incorporation of bentonite into the diets of juvenile rainbow trout (Eya, *et al*., 2008) and pigs (Trckova *et al*., 2004) had no adverse effects on performance and whole-body composition. Inclusion of bentonite at 5% was the optimum level for maximum percent weight gain, specific growth rate and feed efficiency (Eya *et al.*, 2008). Additional studies are necessary to clearly determine the mechanism responsible for the beneficial effects of these zeolites (Eya, *et al.*, 2008). Bentonite resources are estimated to be about twelve million tons in Iran (Safaeikatouli *et al.*, 2010). Little information has been published showing the effects of Bentonite on broiler performance and passage rate of diet in gastrointestinal track (Damiri *et al.*, 2011). Therefore, the objective of present research was to find optimum sodium bentonite levels on performance, carcass characteristics and passage rate of broiler chickens.

MATERIALS AND METHODS

The study involved 288 broiler chickens (1-day-old, Ross 288) which were randomly allocated to 6 experimental treatments, which consisted of four replicates of 12 birds each. The birds were fed a balanced commercial broiler ration ad libitum for a period of six weeks. Treatments were 0.00, 0.75, 1.50, 2.25, 3.00 and 3.75% of SB levels for starter (0-21 days) and grower (22-42 days) periods. Diets were formulated according to NRC (1994) recommendations (Table 1). Weight gain, feed consumption and feed conversion ratio (FCR) were calculated on weekly basis. At day 36, broilers were fasted for 12 h and provided with water *ad libitum.* At the end of fasting period, broilers were given respective treatment diets, which had been mixed thoroughly with 2% (w/w) titanium oxide as marker. After 1 h, feed intake was recorded and marked feed was replaced with normal treatment diets. Excreta were collected hourly for the first 8 h and at 12, 24, and 36 h after the birds received the marked feeds. Excreta from each cage was collected, kept in plastic bags and stored at −20°C before drying at 60°C to constant weight (Sieo *et al.*, 2005). After drying, excreta were equilibrated with atmospheric moisture, weighed, ground, sieved through a 1 mm sieve and kept in air tight plastic bottles (100 mL) until used for analyses. A sample of each marked treatment diet was obtained and processed through the same procedure. Titanium content of samples was measured using an atomic absorption spectro photometer. Titanium oxide excreted was expressed as cumulative fractions of the total amount of titanium oxide determined at various sampling times during the 48-h collection period. The cumulative excretion curves of each diet were plotted and fitted to the Hill equation as recommended by Almirall and Esteve-Garcia (1994). Performance and carcass data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) in a completely randomized design.

RESULTS

Feed consumption, weight gain, and FCR of broilers fed diets containing different SB levels are given in Table 2, 3 and 4, respectively. Chickens fed diets contained SB consumed more feed ($P<0.05$). Feed intake at starter and grower phase in all weeks (1, 2, 3, 4, 5 and 6) was different between diets ($P<0.05$). Maximum feed consumption was observed in broilers fed ration containing 0.75 and 2.25% SB, while minimum feed intake was noted in 3.75% SB ($P<0.05$) treatment.

Feeding SB to broilers had no effect on weight gain during whole the experimental period, but 2.25 and 3.00% improved that in compare to control diet. At starter phase, diets contained 0.75% SB had the most weight gain, and least weight gain was for 3.75% SB in diet ($P<0.05$). However, there was not any difference between diets, but diet contained 3.75% SB had the best FCR.

The results of relative organ weights (relative to body weights) are shown in table 4. As percentage of SB increased in diet the relative weight of liver decreased. Control groups had the highest relative weight of breast ($P<0.05$).

Data obtained from experiment indicated that supplementation of diet by SB increased retention time and decreased passage rate of diets (Table 6). Passage rate of birds that consumed diets contained 2.25% SB was the lowest amount ($P<0.05$). Sodium bentonite increased feed intake and except diet contained 3.75% SB, feed intake in all diets was more than control.

Table 1: Ingredients and chemical composition of diet

Ingredient	Starter diet	Diet grower
Corn (%)	59.00	63.00
Sodium bentonite (%)	0.00	0.00
Soybean Meal (%)	32.03	27.79
Fish meal (%)	3.00	2.50
Oil (%)	1.81	3.25
DCP (%)	1.50	0.90
Oyster (%)	1.50	1.55
Vit. & Min. Premix (%)	0.50	0.50
Common Salt (%)	0.40	0.32
DL-Methionine (%)	0.2	0.1
L-Lysine (%)	0.07	0.09
Chemical compositions		
ME (Kcal/kg)	3070	3100
Protein (%)	21.20	19.37
Calcium (%)	1.10	0.96
Phosphorous (%)	0.50	0.37
Lysine (%)	1.26	1.14
Met+Cys (%)	0.91	0.76

DCP: Di-calcium phosphate; ME: Metabolizable energy; Vit. & Min.: Vitamin and mineral. Vitamin-mineral premix: Supplied/kg diet: vitamin A 8,050 IU; cholecalciferol 1,800 IU; vitamin E 20 IU; vitamin K3 5.1 mg; thiamin 2.4 mg; riboflavin 8.2 mg; pantothenic acid 15.3 mg; pyridoxine 3.1 mg; cobalamin 0.02 mg; niacin 32 mg; choline chloride 1,000 mg; biotin 0.20 mg; folic acid 1.2 mg; Mn 68 mg; Fe 85 mg; Zn 58 mg; Cu 8.6 mg; I 0.27 mg and Se 0.20 mg.

DISCUSSION

Results of feed intake are in agree with the findings of Pasha *et al.* (2008), who used different bentonite levels in broiler diets and reported more feed intake in chicks fed higher levels of SB (1% SB) than control. In contrast with our results, no significant effect in rats (Demirel *et al.*, 2011), and a decrease in feed intake with adding 2, 3 and 4% SB to diets has been reported in broiler chicks (Tauqir and Nawaz, 2001).

The results of Tauqir and Nawaz (2001) showed that 1, 2 and 3% SB improved ($P<0.05$) weight gain, feed efficiency and final weight, but 4% SB decrease them; also Pasha *et al.* (2008) reported these improvements in broilers by 0.5 and 1% SB, which confirmed the results of present experiment. More desirable results by addition low levels of SB (3% and less) may be due to increased retention time of digesta in lumen and more utilization of

Table 2: Effect of different sodium bentonite levels on feed intake (g) of broilers

Bentonite %	Week 1	Week 2	Week 3	Starter phase	Week 4	Week 5	Week 6	grower phase	1-6 week
0.00	112.6^{ab}	292.63^{ab}	477.50^{ab}	882.80^{ab}	684.81^{bc}	944.20	1144.95^{ab}	2773.96^{ab}	3656.70^{ab}
0.75	122.0^{a}	309.19^{a}	505.73^{a}	937.00^{a}	723.96^{ab}	951.67	1152.50^{ab}	2828.12^{ab}	3765.12^{a}
1.50	121.3^{a}	300.80^{ab}	487.27^{ab}	911.36^{ab}	723.74^{ab}	900.02	1126.35^{ab}	2750.11^{ab}	3661.46^{ab}
2.25	115.4^{ab}	303.20^{a}	474.51^{ab}	893.13^{ab}	730.81^{a}	956.97	1186.54^{a}	2874.31^{a}	3767.44^{a}
3.00	111.4^{ab}	302.73^{ab}	490.55^{ab}	904.74^{ab}	702.60^{abc}	938.07	1160.74^{ab}	2801.41^{ab}	3706.15^{ab}
3.75	109.0^{b}	275.65^{b}	467.17^{b}	851.90^{b}	678.90^{c}	916.41	1079.55^{b}	2674.87^{b}	3526.77^{b}
SEM	3.65	9.44	13.52	17.6	18.27	22.52	29.82	56.58	34.44

Values with different superscripts in each column are significantly different (P<0.05); SEM: Standard error of mean.

Table 3: Effect of different sodium bentonite levels on weight again (g) of broilers

Bentonite %	Week 1	Week 2	Week 3	Starter phase	Week 4	Week 5	Week 6	grower phase	1-6 week
0.00	87.9	183.3	285.6^{a}	556.92^{ab}	302.5	454.05^{a}	475.2	1231.7	1788.6
0.75	93.7	197.6	284.6^{a}	576.04^{a}	288.5	432.71^{ab}	490.6	1211.8	1787.9
1.50	92.0	198.6	277.7^{ab}	568.39^{a}	302.5	407.63^{a}	505.0	1215.2	1783.6
2.25	89.3	192.6	264.2^{ab}	546.27^{ab}	300.4	461.23^{a}	543.8	1305.5	1851.7
3.00	91.3	186.5	267.8^{ab}	545.76^{ab}	273.52	454.64^{a}	535.8	1263.9	1809.7
3.75	103.5	162.2	258.7^{b}	524.44^{b}	286.97	451.89^{a}	483.3	1222.2	1746.6
SEM	6.28	6.54	6.58	10.51	14.93	21.38	26.50	32.46	36.00

Values with different superscripts in each column are significantly different (P<0.05); SEM: Standard error of mean.

Table 4: Effect of different sodium bentonite on feed conversion ratio of broilers

Bentonite %	Week 1	Week 2	Week 3	Starter phase	Week 4	Week 5	Week 6	grower phase	1-6 week
0.00	1.29^{a}	1.60	1.67^{b}	1.52	2.27	2.08^{a}	2.45	2.27	1.89
0.75	1.30^{a}	1.56	1.77^{ab}	1.54	2.51	2.20^{a}	2.35	2.35	1.95
1.50	1.31^{a}	1.51	1.76^{ab}	1.53	2.42	2.20^{a}	2.23	2.29	1.91
2.25	1.29^{a}	1.57	1.80^{a}	1.55	2.44	2.07^{b}	2.19	2.23	1.89
3.00	1.23^{ab}	1.62	1.83^{a}	1.56	2.58	2.06^{b}	2.18	2.28	1.92
3.75	1.08^{b}	1.72	1.81^{a}	1.53	2.37	2.03^{b}	2.24	2.21	1.87
SEM	0.061	0.075	0.038	0.021	0.100	0.041	0.108	0.047	0.030

Values with different superscripts in each column are significantly different (P<0.05); SEM: Standard error of mean.

Table 5: Effect of different sodium bentonite levels on carcass traits of broilers (g)

Bentonite %	carcass components			
	Breast	Thigh	Gizzard	Liver
0.00	22.0^{a}	31	3.39	2.77^{a}
0.75	19.4^{ab}	31.5	3.84	2.68^{a}
1.50	17.7^{b}	31.3	3.60	2.65^{a}
2.25	20.2^{ab}	34.3	3.77	2.73^{a}
3.00	21.3^{ab}	30.0	3.94	2.49^{a}
3.75	20.1^{ab}	31.0	3.59	2.16^{b}
SEM	0.95	1.44	0.19	0.11

Values with different superscripts in each column are significantly different (P<0.05); SEM: Standard error of mean.

Table 6: Effect of different SB level on passage rate of broilers

Bentonite %	Intake (g)	Retention time (h)	Time delay (h)	Passage rate (kg/h)
0.00	1828.38^{ab}	12.54^{c}	2.55	0.121^{a}
0.75	1882.56^{a}	20.88^{b}	2.37	0.059^{b}
1.50	1830.74^{ab}	18.43^{b}	2.50	0.070^{b}
2.25	1883.72^{a}	22.25^{a}	2.42	0.058^{b}
3.00	1853.07^{ab}	25.45^{a}	1.98	0.047^{c}
3.75	1763.38^{b}	24.90^{a}	2.32	0.049^{c}
SEM	34.444	1.08	0.89	0.002

Values with different superscripts in each column are significantly different; (P<0.05); SEM: Standard error means.

nutrients (Table 6). It is evident from Table 6 that adding 3% SB increased feed intake, therefore increasing of retention time had no negative effects on intake, and even increased performance. Low weight gain and feed intake at higher levels of sodium bentonite (3.75%) was in agreed with the results of Tauqir and Nawaz (2001). It may be due to viscose nature of Bentonite which absorbs much water and decreased passage rate of digesta more than normal in lumen, which may affect feed intake and other characteristics negatively. Addition of 3.75% SB to diet decreased feed intake and some parameter of performance such as weight again.

During present experiment SB had no significant effect on FCR. It is reported in some literatures, that SB had no effect on FCR (Demirel *et al.,* 2011), where weight gain in chickens given low energy diets was not affected by bentonite, this was attributed to the interaction of SB with low energy. In contrast, increased FCR in birds fed on rations supplemented with SB has been reported (Tauqir and Nawaz, 2001; Xia *et al*., 2005; Pasha *et al*., 2008).

As percentage of SB increased the relative weight of liver decreased (P<0.05). This may was due to binding toxic agent such as aflatoxins by SB. Poultry are highly sensitive to aflatoxins, and most conspicuous poisoning effects observed in poultry (Eraslan *et al*., 2004a) and quails (Eraslan *et al*., 2004b) is damage to the liver and increasing its mass and weight, growth retardation; decreased feed intake and weakening of the immune system. Incorporation of binding agents to feed at certain rates is one of the most commonly used measures (Eraslan *et al*., 2005). These binding agents have adsorbent structure and contain aluminosilicates like SB. Sodium and calcium, which are present in the chemical structures of these compounds, increase their binding capacity. Consequently, an irreversible structure is formed in the digestive tract as a result of interaction between binding agent and aflatoxins; and the absorption of aflatoxins is limited (Phillips *et al*., 1994).

It is concluded, that addition 2.25-3.00% SB to broiler diets had benefits effects on performance, carcass characteristics and passage rate, therefore resulted in improved efficiency of production.

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