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Effects of Dietary Supplementation with Perlite and Zeolite on Performance, Litter Quality and Carcass Characteristics of Broilers from 7-42 Days of Age

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Abstract

An experiment with 300 one-day-old Ross mixed-sex broiler chicks was conducted to determine the effects of perlite and zeolite on broiler performance, litter quality and carcass characteristics. Five experimental diets [control, perlite (2 or 4 %), zeolite (2 or 4 %)] were formulated according to NRC (1994) recommendation for starter and grower phases. The experimental design was a completely randomized with 4 replicates of 15 chicks each. During the experiment, energy efficiency ratio (EER) and European efficiency factor (EEF) were measured at starter (7-21 d) and grower phase (21-42 d). Litter moisture and nitrogen were also measured at 21 and 42 d at the end of experiment, two chicks per replicate were slaughtered to determine carcass characteristics. The results indicated that except for 4 % perlite supplemented group, control group had significantly higher EER compared to other treatments (P<0.05). Also, 2 % perlite supplementation to the diet decreased litter moisture, significantly at 42 d (P<0.05). Litter nitrogen content was decreased significantly by dietary supplementation of 4 % zeolite at 42 d (P<0.05). There were no significant differences (P>0.05) among treatments during the experiment for EEF and carcass characteristics, although, 4 % perlite supplemented group had the highest carcass performance, numerically.

Keywords: Broiler; Carcass; Litter; Perlite; Zeolite.

Introduction

Perlite is not a trade name but a generic term for naturally occurring siliceous volcanic rock. Perlite is a natural nonzeolite aluminosilicate that have no charge or ion exchange capacity (Scheideler, 1993). The distinguishing feature which sets perlite apart from other volcanic glasses is that, when heated to a suitable point in its softening range, it expands from four to twenty times its original volume (Schundler Product Guide, 2002). The uses of expended perlite are many and varied and are based primarily upon its physical and chemical properties. Because, perlite has greater than 70 % silica, therefore it has adsorptive and chemically inert properties (Chesterman, 1975). Recently, application of expanded perlite in animal feeding is increased. However, reports about this application are scarce.

Zeolites are important group of hydrated aluminosilicates (AS) of alkali and alkaline earth cations that have an infinite, three dimensional structures. Zeolites are naturally found in abundance all over the world and have the composition of $CaNa_4K_4(AlO_2)_6(SiO_2)_{30}.24H_2O$. Zeolites have the ability to lose water and gain water reversibly and to exchange constituent cations without major changes of structure (Mumpton and Fishman, 1977). (Table1).

In last decade, some reports were available about application of perlite in broiler nutrition. Scheideler (1993) reported that perlite did not have any effect on bone ash percentage of broilers. Tatar et al. (2008a) demonstrated that by 2.5 % perlite supplementation of broiler's diet, increased weight gain, significantly. Similarly, Ghiasi Ghalehkandi et al. (2011) showed that broilers fed perlite had better performance. Tatar et al. (2008b) compared broiler chicks with perlite supplementation and control treatment. They showed there were no significant differences in weight gain, feed intake and feed conversion ratio among treatments. Jenabi Shelmani et al. (2010) and Ebadi Azar et al. (2011) showed that expanded perlite supplementation of Japanese quail and broiler diet had no effect on carcass characteristics, except gizzard weight.

Table 1. Chemical composition (major oxides) of natural perlite and zeolite used in the experiment (%).

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	MnO	L.O.I
Perlite[1]	69.39	14.67	1.16	0.30	1.07	0.5	0.79	0.16	-	0.91	-	11
Zeolite[2]	66	11.43	1.30	3.11	0.72	2.01	3.12	0.21	0.01	-	0.04	12.05

[1] Mana et al. (2007)
[2] As report of producer company, Iran
L.O.I: Loss on ignition at 1000 °C.

It was shown that 3 % (Safaei Katouli et al., 2012) and 4 % (Zarin Kavyani et al., 2007) zeolite supplementation to the diet of broiler and Lohmann chicks, respectively, improved European Efficiency Factor (EEF) significantly. Kiaei et al. (2002), demonstrated that natural zeolite in broiler ration did not have any effect on litter moisture. They believed that silicate minerals by stimulating gastrointestinal tract can improve the digestibility of diet as well as broiler performance. Mechanically stimulated gastrointestinal epithelial cells due to increased mucosal morphology and the level of gastrointestinal absorption of the small intestine improve digestion and absorption of nutrients.

The notion is that excreta, feed, feathers and bedding material are all components of poultry litter (Nahm, 2005). The evidence in the literature suggests that excreta and litter moisture and quality are associated with health, performance and welfare of broilers and hens whereas they may be a source of environmental and management problems in commercial poultry industry (Blair et al., 1999; Al-Homidan et al., 2003; Islam et al., 2003). There is also evidence of intense research efforts towards various methods to reduce the pollutants released from poultry farms. In the case of poultry, particularly, there has been recently a new interest in the use natural zeolites as a means of reducing odor and ammonia emissions from broiler houses (Amon et al., 1997; McCrory and Hobbs, 2001), as feed additive (Onagi, 1965; Nakaeu et al., 1981; Christaki et al., 2001; Suchy et al., 2006; Karamanlis et al., 2008) and as supplement in bedding materials (Ullman et al., 2004; Pour Reza et al., 2004; Eleroglu; and Yalcin. 2005; and Turan et al., 2009).

The aim of this study was to determine the effects of perlite and zeolite supplementation in broiler diets on performance, litter quality and carcass characteristics from 7-42 d of age.

Materials and Methods

Experimental design and diet

A total of 300 one-day-old Ross mixed-sex broiler chicks obtained from a commercial hatchery were transported to environmentally controlled poultry shed at Makian Mehr Gonbad Co. (Gonbad-e-Kavoos, Iran) and housed into 20 floors deep litter pens with 15 chicks each. Chicks were weighed at d 7 and allocated in a completely randomized experimental design from 7-42 days of age. The treatments were: control, 2 % perlite, 4 % perlite, 2 % zeolite and 4 % zeolite (Table 2). There were 4 replicates for each treatment. All diets were formulated to meet National Research Council (1994) requirements. The starter (7-21 d) and grower (21-42 d) diets were isonitrogenous and isocaloric.

Feed and water were provided *ad libitum*. Temperature was kept constant at 32°C from 0 to 7 d and progressively reduced to reach 18°C at 35 d and remained constant until 42 d. Lighting was 24 h/day during the 42 d.

Collection and analysis of samples

Energy efficiency ratio (EER) was calculated for each phase as grams of weight gain×100/total ME intake (Kamran et al., 2008). Another performance indicator was the EEF calculated as method described by Lemme et al. (2006), (final bird weight, kg × liveability, %)/(age, days × feed conversion ratio × 100). Over time we have moved from a simple measurement of bird weight, to weight for age, mortality, FCR and more recently to an EEF. The advantage of using EEF is that all of the factors mentioned above are considered simultaneously and it gives us a reasonable idea of overall technical efficiency.

At 21 and 42 d, broiler litter samples (2.5 cm in diameter and the depth of the litter in the pen) were collected for determination of its moisture and nitrogen content (McGrath et al., 2005).

At 42 d, four males and four females/treatment, having a body weight comparable with the pen average weight, 40 birds in total, were selected randomly and slaughtered by cutting neck to determine weights of carcass, breast with bone and without skin, thighs without skin, distal back, drumsticks and abdominal fat. Weights were expressed as percentage of live body weight (Huyghebaert and Pack, 1996).

Statistical analysis

The experiment was conducted in a completely randomized design. The data were subjected to two-way ANOVA using the General Linear Models procedure (SAS institute, 1999) and represented as the mean ± SE. Duncan's multiple range test was used to separate significant means (Duncan, 1955). The level of significance used in all results was $P<0.05$ according to methods described by Steel and Torrie (1960).

Results and Discussion

Performance

Changes in energy efficiency ratio (EER) and European efficiency factor (EEF) are shown in Table 3. The EER results were significant at starter, grower and overall phase. At starter phase, 4 % zeolite supplementation led to significant increase in EER compared to 2 % perlite supplementation ($P<0.05$). Conversely, at grower phase, EER in control group showed a significant increase compared to 4 % zeolite supplementation. Overall phase data demonstrated that similar to grower phase, control treatment had increased EER in comparison with 2 % perlite and zeolite supplemented treatments ($P<0.05$). EEF results indicated that adding 2 and 4 % perlite or zeolite to diet, did not have an effect on EEF at overall rearing period ($P>0.05$).

Table 2. Composition of the experimental diets

	Starter			Grower		
Ingredient (%)	Control	2 %	4 %	Control	2 %	4 %
Corn	54.78	50.91	47.04	61.03	57.17	53.31
Soybean meal (44% CP)	39.40	40.05	40.70	33.48	34.13	34.78
Soybean oil	1.96	3.17	4.38	2.20	3.41	4.62
Limestone	1.13	1.13	1.12	1.33	1.32	1.32
Dicalcium phosphate	1.60	1.61	1.62	1.03	1.03	1.03
Salt	0.42	0.42	0.42	0.32	0.32	0.32
Vitamin premix[1]	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.12	0.13	0.13	0.04	0.05	0.05
Vitamin E	0.03	0.03	0.03	0.03	0.03	0.03
Salynomycine	0.05	0.05	0.05	0.05	0.05	0.05
Perlite/ Zeolite	-	2	4	-	2	4
Calculated analysis,%						
ME, Kcal/kg	2900	2900	2900	3000	3000	3000
Crude protein, %	20.85	20.85	20.85	18.75	18.75	18.75
Ca, %	0.91	0.91	0.91	0.84	0.84	0.84
P, %	0.45	0.45	0.45	0.33	0.33	0.33
Na, %	0.18	0.18	0.18	0.14	0.14	0.14
Lys, %	1.20	1.20	1.20	1.06	1.07	1.07
Arg, %	1.13	1.13	1.13	1.03	1.03	1.03
Met, %	0.46	0.46	0.47	0.36	0.36	0.36
Met+cys, %	0.82	0.82	0.82	0.69	0.69	0.68
Thr, %	0.72	0.72	0.72	0.69	0.69	0.69

[1]Provided per kg of diet: vitamin A, 8,800 IU; vitamin D3, 3,300 IU; vitamin E, 40 IU; vitamin K3, 3.3 mg; thiamine, 4.0 mg; riboflavin, 8.0 mg; panthothenic acid, 15 mg; niacin, 50 mg; pyridoxine, 3.3 mg; choline, 600
mg; folic acid, 1 mg; biotin, 220 μg; vitamin B12, 12 μg; ethoxyquin, 120 mg; manganese, 70 mg; zinc, 70 mg;

iron, 60 mg; copper, 10 mg; iodine, 1.0 mg; and selenium, 0.3 mg.

The results regarding EER were consistent with the findings of Safaei Katuli et al. (2012) who observed that adding 3 % natural zeolite on broiler's diet, led to significant increase in EER compared to control groups at starter phase. But, their EER data at overall phase, converse to our results. Evaluating broiler performance is complex. The results about EEF showed that there were no significant differences among dietary treatments (P>0.05) but, there were some numerically differences. For example, at starter phase 4 % perlite treatment had higher EEF numerically and control group at grower and total phase numerically compared to other treatments. However, EEF related results were not supported by Jenabi Shelmani et al. (2010) who added 1.5 and 3 % perlite and zeolite in Japanese quail diet and reported that 1.5 % perlite supplementation resulted in more and significant EEF compared to other treatments.

Table 3. Effects of dietary treatments on performance of broilers from 7 to 42 d.

Dietary treatments	Energy efficiency ratio, %			European efficiency factor		
	7 to 21 d	21 to 42 d	7 to 42 d	7 to 21 d	21 to 42 d	7 to 42 d
Control	13.79 ± 041 ^{ab}	20.32 ± 1.23 ^{a}	34.30 ± 1.39 ^{a}	87.39 ± 6.69	99.81 ± 7.22	98.11 ± 7.32
Perlite, 2 %	12.98 ± 0.57 ^{b}	17.52 ± 0.67 ^{ab}	30.57 ± 0.95 ^{b}	82.49 ± 3.68	90.06 ± 1.91	88.43 ± 2.08
Perlite, 4 %	13.82 ± 0.25 ^{ab}	18.22 ± 0.74 ^{ab}	32.11 ± 0.64 ^{ab}	93.05 ± 5.27	98.93 ± 2.82	97.49 ± 2.50
Zeolite, 2 %	13.29 ± 0.26 ^{ab}	17.12 ± 1.35 ^{ab}	30.47 ± 1.48 ^{b}	83.57 ± 9.83	88.95 ± 8.52	88.31 ± 8.68
Zeolite, 4 %	14.89 ± 0.97 ^{a}	15.41 ± 1.33 ^{b}	30.30 ± 1.19 ^{b}	86.21 ± 7.28	92.98 ± 5.70	91.15 ± 5.59
P-value	0.2074	0.0780	0.1317	0.8316	0.5786	0.6201

Values with a different superscript in the same column are significantly different (P<0.05). Mean ± SE.

Litter Quality

Results for litter quality are shown in Table 4. There were no significant differences in litter moisture and nitrogen at 21 d (P>0.05). But, litter moisture was severely depressed during the grower phase with 2 % perlite supplementation. However, the results for litter moisture were consistent with the findings of Onagi (1965) and Nakaue et al. (1981) who observed that litter moisture was decreased significantly with dietary treatment by natural zeolites. Results for litter moisture were not supported by Kiaei et al. (2002) who reported no changes in litter moisture by zeolite supplementation to broiler diets. Regarding litter nitrogen content there were significant differences among treatments only at grower phase. The results demonstrated that, at grower phase, after adding 4 % zeolite to diet, litter nitrogen content decreased significantly compared to other treatments, except for 4 % perlite treatment. The results are in agreement with reports of Airoldi et al. (1993); Cabuk et al. (2004); Karamanlis et al. (2008) and Turan et al. (2009).

Both ion-exchange and adsorption properties of natural zeolites can be exploited to make more efficient use of them for nitrogen and ammonia production in poultry excreta (Mumpton and Fishman, 1977). The cation selectivity is:

Cs > Rb > K > NH_4 > Ba > Sr > Na > Ca > Fe > Al > Mg > Li (Ames, 1960)

Thus, zeolite has a decided preference for larger cations and its selectivity for NH_4^+ ions was exploited by Ames (1967) and Mercer et al. (1970).

Nakaue and Koelliker (1981) evaluated zeolites as a broiler feed additive and found that incorporation of 10 % zeolite to the feed of the birds throughout their lifetime reduced aerial NH_3 concentration by up to 8 %.

Table 4. Effects of dietary treatments on litter quality parameters at 21 and 42 d.

Dietary treatments	Moisture, %		Nitrogen, %	
	21 d	42 d	21 d	42 d
Control	11.23 ± 1.83	11.75 ± 1.29 ^{ab}	3.68 ± 0.27	3.69 ± 0.08 ^{ab}
Perlite, 2 %	10.55 ± 0.92	8.71 ± 0.20 ^{b}	3.74 ± 0.16	3.90 ± 0.07 ^{a}
Perlite, 4 %	10.86 ± 0.41	13.14 ± 0.75 ^{a}	3.85 ± 0.17	3.44 ± 0.14 ^{bc}
Zeolite, 2 %	10.81 ± 1.59	11.23 ± 1.53 ^{ab}	3.58 ± 0.25	3.84 ± 0.09 ^{a}
Zeolite, 4 %	13.76 ± 1.68	12.90 ± 0.67 ^{a}	3.32 ± 0.17	3.21 ± 0.05 ^{c}
P-value	0.4891	0.0480	0.4968	0.0005

Values with a different superscript in the same column are significantly different (P<0.05). Mean ± SE.

Carcass characteristics

Effects of dietary treatments on carcass characteristics at 42 d were demonstrated in Table 5. No significant differences were observed among the experimental treatments for carcass weight, breast meat, thighs, distal back and drumsticks and abdominal fat relative weight percentage (P>0.05). However, 4 % perlite treatment shown highest carcass characteristics data numerically in relation to other treatments. These results were consistent with the findings of Yalcin et al. (1995), Lotfollahian et al. (2004) and Tatar et al. (2008a) who observed that adding natural zeolite (Yalcin et al., 1995; Lotfollahian et al., 2004) or perlite (Tatar et al., 2008a) do not have significant effect on carcass characteristics of broiler chickens. Conversely, Palic et al. (1993) and Safaei Katuli et al. (2012) concluded that using dietary zeolite increased meat production of broilers and consequently yielded higher pectoral and thigh weight percentage which can be due to the effect of aluminosilicates in improving the gastrointestinal tract health and feed conversion ratio.

Conclusion

The results of the experiment, showed beneficial effects of perlite on litter moisture and zeolite on litter nitrogen and finally health and welfare of broiler chickens. But, more research is needed to evaluate perlite effects on broiler performance and health parameters.

Table 5. Mean comparison of carcass characteristics at 42 d (% of live weight).

Carcass characteristics	Control	Perlite		Zeolite		P-value
		2 %	4 %	2 %	4 %	
Carcass	52.26 ± 0.20	52.55 ± 0.78	55.34 ± 0.78	53.20 ± 0.82	53.17 ± 1.33	0.94
Breast meat	17.53 ± 0.50	18.86 ± 0.57	19.62 ± 1.08	18.16 ± 1.03	18.63 ± 0.96	0.81
Thighs	16.64 ± 0.25	16.26 ± 0.80	16.86 ± 0.50	16.61 ± 0.84	16.66 ± 0.25	0.13
Distal back and drumsticks	18.09 ± 0.97	17.24 ± 0.38	18.86 ± 0.23	18.43 ± 0.65	17.88 ± 0.41	0.86
Abdominal fat	1.49 ± 0.36	1.52 ± 0.29	1.31 ± 0.27	2.00 ± 0.31	1.86 ± 0.43	0.71

Mean ± SE.

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