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Effects of different levels of expanded perlite on the performance and egg quality traits of laying hens

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ABSTRACT - The influence of different levels of expanded perlite on the performance and egg quality traits was studied in laying hens. Forty Lohmann Brown females at 30 weeks of age were randomly assigned to four groups consisting of five replicates with two hens in each. Four diet groups were supplemented with 0% (control group), 1%, 2%, and 3% perlite, respectively. Feed and water were provided *ad libitum*. There were no significant differences in final body weight, feed intake, egg yield, and egg weight. Feed conversion ratio and egg weight decreased with addition of 2% perlite. Dietary perlite supplementation has no significant effects on shape, yolk, and albumen index. Haugh unit was affected significantly by addition of 2% perlite. Fecal pH, dry matter, and NH_3-N did not significantly differ among treatments. Dietary perlite has no negative effect on performance and egg quality traits except 2% perlite group. Dietary expanded perlite can be added at 1% level in laying hen rations without changing the animal performance.

Key Words: egg, performance, perlite, poultry

Introduction

Perlite is a glassy volcanic rock (Tekin, 2004). The name of "perlit" is derived from the word "perle", which means pearl (Orhun, 1969). Raw perlite is transparent and greyish or gloss black rock of hydrated aluminosilicates of alkali (i.e., Na+, K+) and alkaline earth cations (Ghalehkandi et al., 2014). Perlite expands by 10-30 times its original volume when heated up to 700-1200 °C. This expansion is due to the presence of two to six percent combined water in the crude perlite rock. Expanded perlite is an excellent thermal and acoustical insulator; it resists fire, and is an ultra-lightweight material (Talebali and Farzinpour, 2006). Perlite is used in construction industry, insulation tiles, and concrete as aggregate. Expanded perlite is commonly used for herbicides, insecticides, and fertilizer as a carrier (Tekin, 2004). Moreover, it is commonly used in the processing of vegetable fat, juice, and beer in food industry. Also, it is used as a filter product in cleaning of dams and ponds in aquatic environment to obtain a clear liquid, growing of seed, regulating of the soil in agriculture, and in so many other industrial applications (Alihosseini et al., 2010). Perlite has recently been used as an aflatoxin detoxicant and adsorbent in the removal of wastewater (Talebali and Farzinpour, 2006).

Feed constitutes approximately 70% of the cost in the poultry sector. After the usage of antibiotics were banned, researchers started to study on natural and synthetic feed additives to reduce feed costs and improve the quality of feed (Çelebi and Kaya, 2012). Some researchers have focused on perlite (Orhun, 1969; Talebali and Farzinpour, 2006), zeolite (Eleroğlu et al., 2011; Tatar et al., 2012), and sepiolite (Mızrak et al., 2014; Kavan et al., 2013). Perlite was found in Germany in 1925. Actually, the perlite industry began to develop in the United States in 1947 (Orhun, 1969). Turkey is one of the most important perlite producer countries; approximately 400,000 t perlite were produced in 2012 (Anonymus, 2013).

Zeolite, a hydrated aluminosilicate of alkali and alkaline soil cations, was discovered by mineralogist Fedrik Costeldt in 1756 (Çelebi and Kaya, 2012; Tatar et al., 2012). The zeolite structure is a specific arrangement, in which the unit cell contains 24 tetrahedra, 12 AlO_4, and 12 SiO_4. When fully hydrated, there are 27 water molecules and there is also one monovalent cation for each aluminum present (Kermanshahi et al., 2011). Dietary addition of zeolite has been shown to decrease the ammonia toxicity and aflatoxin toxicity in feedstuffs such as corn, wheat, and soybean (Miazzo et al., 2000).

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Sepiolite is an opaque and off-white, grey, or cream-color natural mineral used in animal nutrition. It has high adsorption capacity (Mızrak et al., 2014). Sepiolite differs from the other clay minerals in terms of rheology importance. It is known as a relatively good ion exchanger due to its magnesium ion in the octahedral layer. (Mızrak et al., 2014). Magnesium ion releases more quickly, especially at low pH values. Transfer to a water solution of Mg at neutral pH (approximately 8.5) is 10^{-4} mol/L, increasing to 10^{-2} at pH = 3 (Mızrak et al., 2013). Maximum viscosity value of sepiolite pH is 8 (Mart et al., 2001). Mızrak et al. (2013) reported that shape index, eggshell weight and thickness, albumen height, and Haugh unit were not affected by adding sepiolite (1-2%).

The objective of this study was to investigate the effects of different dietary levels of expanded perlite on performance and egg quality traits of laying hens.

Material and Methods

All experimental procedures used in this study were approved by the Animal Ethics Committee of the University of Mehmet Akif Ersoy (Burdur - Turkey/case no. 93773921). In total, forty Lohmann Brown laying hens with uniform body weight were obtained from commercial flock at 30 weeks of age. The laying hens were assigned to four equal groups replicated five times with two hens. They were housed in wire cages (30 cm × 44 cm × 44 cm) which were two-tiered and three-sided. Room temperature (18±2 °C) was recorded daily and light program consisted of 16 h of light/day throughout the study. The study consisted of the non-supplemented perlite basal diet (control group). The different inclusion level of perlite (1, 2, and 3%) was added to basal diet weekly. All diets and water were provided *ad libitum* during the seven-week experimental period. The diets were formulated as NRC (1994) requirements (Table 1). Perlite was supplied from Genper Company.

Nutrient composition of concentrates was determined according to the AOAC (2003); crude fiber was determined by the methods of Crampton and Maynard (1938); the metabolizable energy levels (Table 2) of concentrated feeds were determined by the methods of Tittus and Fritz (1971).

The hens were weighed individually at the beginning and end of the study. For each cage, eggs were counted daily and weighed weekly. Feed intake and feed conversion ratio (FCR) were determined weekly. Feed conversion ratio was calculated by determining the amount of feed consumed per one kilogram of egg production and one kilogram of feed per dozen eggs.

Egg quality was determined in 10 eggs collected randomly from 09:30 to 12:30 h from each replicate on two consecutive days biweekly. The egg width (E_W) and egg length (E_L) were measured by digital calipers (Absolute digimatic caliper/series 500) to determine shape index [% = (E_W/E_L) × 100].

The egg was broken onto a glass-topped table. The height of the albumen (A_H) and the yolk (Y_H) was measured with a tripod micrometer (Mitutoyo, No. 2050S-19, 0.01-20 mm; Kawasaki, Japan). To determine yolk index [$Y_I = (Y_H/Y_D) \times 100$], albumen index [$A_I = A_H/[(A_L+A_W)/2] \times 100$], and Haugh unit [$H_U = 100 \log (\text{Albumen height} + 7.57 - 1.7 \times \text{Egg weight}^{0.37})$] (Haugh, 1937), the length (A_L) and width (A_W) of the albumen and the diameter of the yolk (Y_D) were measured using a digital caliper (Yalçın et al., 2014).

The cage of each group was cleaned one day before the end of trial. Fecal samples (n = 20) were collected from litter tray and weighed at the end of trial; then they were dried at 65 °C in a laboratory oven. Then, dry matter was calculated. To determine fecal pH, 25 g sample were mixed to 100 mL distilled water for 5 min with a blender. Fecal

Table 1 - Ingredients of basal diet

Ingredient	g/kg
Wheat	140
Corn	334
Sunflower meal	207
Soybean meal (48% crude protein)	134
Sunflower oil	60
Dicalcium phosphate	16
Limestone	100
Salt	3.5
DL-methionine	2.0
L-lysine hydrochloride	1.0
Vitamin mineral premix[1]	2.5

[1] Vitamin and mineral premix provided per kilogram of diet: vitamin A, 12,000 000 IU; vitamin E, 20,000 mg; manganese, 50,000 mg; iron, 50,000 mg; zinc, 50,000 mg; copper, 10,000 mg; cobalt, 150 mg; selenium, 150 mg.

Table 2 - Chemical composition of the diets (%)

Group	Dry matter	Ash	Organic matter	Crude protein	Ether extract	Crude fiber	Metabolizable energy[1] (kcal/kg)
Control	90.36	10.38	79.98	16.90	8.08	3.27	2500
1% perlite	90.04	12.90	77.14	16.97	8.61	3.86	2415
2% perlite	90.42	15.16	75.26	16.82	9.07	3.30	2390
3% perlite	90.78	15.52	75.26	16.84	8.48	3.40	2370

[1] MJ/g = 133.06 (crude protein) + 232.91 (ether extract) – 4.68 (crude fiber) + 122.77 (nitrogen-free extract) (Tittus and Fritz, 1971).

pH was measured using pH meter from this filtrate (Polan et al., 1998). This filtrate was centrifuged at 4200 rpm for 10 min and then NH_3-N was determined with distillation (Filya et al., 1997).

Statistical analyses were carried out using SPSS program (SPSS Inc., Chicago, IL, USA). Data were analyzed in one-way ANOVA and significant differences were calculated using Duncan's test (Dawson and Trapp, 2001). Level of significance was taken as P<0.05.

Results and Discussion

Dietary treatments did not significantly affect final body weight, feed intake, and egg yield (Table 3). However, FCR was increased (P = 0.02) and egg weight was decreased (P = 0.03) significantly by addition of 2% perlite. While few studies have been carried out on the effects of perlite on performance of broiler chickens (Talebali and Farzinpour, 2006; Ghalehkandi et al., 2011; Tatar et al., 2012), no study has been designed with laying hens. Ghalehkandi et al. (2011) reported that weight gain was significantly affected by 2% perlite treatment rather than 4% perlite treatment and control group. Talebali and Farzinpour (2006) added 1, 2, and 3% perlite to broiler ration and reported that the 1% perlite group had significant differences in terms of weight (C: 1397; 1% perlite: 1624 g) and FCR (C: 0.38; 1% perlite: 0.44). Glodek (1980) added perlite to pig ration and found that daily weight gain was higher than in the other groups. According to the author, perlite has a carrier characteristic as an aluminum silicate. Several different silicates (zeolite, aluminosilicates, sepiolite-phyllosilicate) were used in laying hens. Yalçın et al. (1987) reported that adding 4% zeolite to ration of laying hens improved weight gain and FCR. Kavan et al. (2013) found that addition of clinoptilolite (zeolite) to diet caused significant differences in terms of body weight gain and FCR. While some researchers found concordance with the present results (Karamanlis et al., 2008; Abaş et al., 2011), some did not agree with them (Fisinin et al., 1985; Öztürk et al., 1998; Wu et al., 2013). Feed conversion ratio and egg mass had an improvement by adding 1.5% sepiolite (Mızrak et al., 2014). Because the viscosity in the jejenum was reduced by the sepiolite supplementation, the positive effect of sepiolite on the feed conversion was improved (Ouhida et al., 2000). With addition of zeolite to ration, passage rate of feeds through digestive tract was decreased and nutrients were more exposed to digestive tract enzymes (Khambualia et al., 2009). Ghalehkandi et al. (2014) found that different levels of perlite significantly increased average villi height in broilers. Also, the author pointed out that there would be a good relationship between section of intestine and weight gain. Khambualai et al. (2009) reported that addition of 0.5 g/kg zeolite to duck ration increased duodenal villus height and area with corresponding body weight gain.

According to the results of this study, different levels of perlite had no effect on shape index, yolk index, and albumen index (Tables 4, 5, 6 and 7). However, in the 2% perlite group, Haugh unit was decreased significantly and albumen index was numerically lower than in the other groups. Nassiri et al. (2008) reported that addition of zeolite to ration of laying hens reduced Haugh unit. As they state, zeolite reduced phosphorus availability for production of phosphoproteins contained in egg albumen. Olver (2007) did not observe any significant differences in Haugh unit by adding zeolite to ration of hens. Fendri et al. (2012) found a positive effect on albumen weight and egg weight by adding 1% zeolite. Mızrak et al. (2013) reported that shape index, eggshell weight and thickness, albumen height, and Haugh unit were not affected by adding sepiolite (1-2%). Mızrak et al. (2014) observed that using sepiolite (1.5-3%) did not affect the internal and external qualities among groups. Kermanshahi et al. (2011) indicated that addition of zeolite did not significantly affect egg production and egg weight among treatments, but yolk color index was significantly affected.

Dietary treatments did not significantly affect fecal pH, dry matter, and NH_3-N. The pH of the feces of laying hens in 3% perlite was higher than that of the other groups (Table 8). The results of the present study are in agreement with previous findings reported by Mızrak et al. (2014). However, Mızrak et al. (2013) found that fecal pH and dry matter were increased by adding sepiolite (2%).

Table 3 - The effects of different levels of perlite on performance of laying hens

	Control	1% perlite	2% perlite	3% perlite	P-value
Initial body weight (g)	1959.50±64.87	1993.50±52.54	1968.00±42.49	1933.00±56.09	0.89
Final body weight (g)	1948.88±71.53	1918.50±58.09	1956.50±36.06	1871.10±53.96	0.69
Feed intake (kg/day)	0.107±0.02	0.114±0.05	0.113±0.01	0.109±0.02	0.65
Egg yield (%)	98.01±0.74	97.85±1.49	96.42±4.18	98.75±1.01	0.47
Feed conversion ratio (kg feed/dozen eggs)	1.49±0.81	1.40±0.60	1.41±0.26	1.33±0.20	0.15
Feed conversion ratio (kg feed/kg egg)	1.79±0.01b	1.80±0.03b	1.90±0.02a	1.79±0.02b	0.02*
Egg weight (g)	64.94±1.36a	63.46±0.51ab	59.87±0.77c	61.07±0.48bc	0.03*

* Means within rows with different letters are significantly different (P<0.05).

Table 4 - Shape index (%)

Week	Control	1% perlite	2% perlite	3% perlite	P-value
2	78.67±0.97	79.13±0.45	78.88±0.52	78.08±0.53	0.68
4	77.27±0.80	79.23±0.88	78.61±0.75	77.67±0.50	0.26
6	78.24±0.92	79.09±0.86	78.33±0.73	77.87±0.57	0.73
8	77.20±0.78	77.69±0.74	77.36±0.56	79.27±2.12	0.63
0-8	77.85±0.36	78.81±0.40	78.30±0.45	78.24±0.70	0.62

Table 5 -Yolk index (%)

Week	Control	1% perlite	2% perlite	3% perlite	P-value
2	44.22±1.18	44.49±0.56	43.19±0.78	42,72±0.51	0.33
4	43.34±0.83	43.69±0.71	43.74±0.60	43.53±0.82	0.98
6	43.62±0.68	43.23±0.91	42.76±0.71	42.84±0.84	0.86
8	42.48±0.90	43.01±0.63	40.73±0.86	42.10±0.68	0.21
0-8	43.42±0.60	43.61±0.27	42.60±0.47	42.74±0.44	0.32

Table 6 - Albumen index (%)

Week	Control	1% perlite	2% perlite	3% perlite	P-value
2	9.07±0.60	10.14±0.51	8.23±0.36	9.11±0.46	0.06
4	8.50±0.68	10.10±0.56	8.34±0.42	8.95±0.59	0.12
6	8.76±0.94	9.69±0.56	7.48±0.18	8.97±0.64	0.10
8	9.14±0.84	9.62±0.70	7.58±0.30	8.22±0.64	0.12
0-8	8.87±0.74	9.89±0.66	7.91±0.32	8.81±0.65	0.09

Table 7 - Haugh unit

Week	Control	1% perlite	2% perlite	3% perlite	P-value
2	94.25±1.66	97.70±1.41	92.25±1.19	95.32±1.34	0.07
4	92.79±2.32	97.66±1.53	92.51±1.46	94.51±1.64	0.14
6	93.01±2.52	95.12±1.56	89.92±0.66	93.85±2.22	0.26
8	94.64±2.29	96.83±1.87	90.58±0.99	91.33±1.99	0.07
0-8	93.55±1.61ab	96.83±0.87b	91.32±0.62a	93.69±1.33ab	0.02*

* Means within row with different letters are significantly different (P<0.05).

Table 8 - Effects of different levels of perlite on some fecal parameters

	Control	1% perlite	2% perlite	3% perlite	P-value
Fecal pH	6.47	6.50	6.49	6.67	0.54
Fecal dry matter	33.23	32.70	31.03	31.74	0.84
Fecal NH_3-N (mg/g dry matter of feces)	1.15	1.30	1.22	1.36	0.93

Conclusions

Dietary perlite supplementation has no significant effects on shape, yolk, and albumen index and no negative effect on performance and egg quality traits, except at 2% level. Dietary expanded perlite can be added at 1% level in laying hen rations without changing the animal performance.

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