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Influence of Natural Zeolite on Performance of Laying Hens and Egg Quality

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Abstract: This experiment was conducted to study the effects of natural zeolite on the performance of laying hens. One hundred and eighty 37-week-old Babcock B-300 hens were fed with a diet containing 0, 20, 40, 60 and 80 g clinoptilolite/kg in an experiment consisting of 36 hens per treatment during a 4x28 days experimental period. All feeding programs were isocaloric and isonitrogenous. Hens were put at random into 5 treatment groups (12 replicates and 36 hens per treatment). No significant dietary effects were observed in terms of body weight, feed consumption, feed efficiency ratio, the number of eggs laid per hen, shell thickness, mortality or other criteria of egg quality (P>.05). Significant dietary effects of clinoptilolite feeding were observed in the form of a decrease in faecal moisture content (P<.05).

Yumurta Tavuklarının Performansı ve Yumurta Kalitesi Üzerine Doğal Zeolitin Etkisi

Özet: Bu çalışma, bir doğal zeolit olan *clinoptilolitin* yumurta tavuklarının performansı ve yumurta kalitesi üzerine olan etkilerini belirlemek için yapılmıştır. Denemede 180 adet, 37 haftalık Babcock-B-300 beyaz yumurtacı hibrit; enerji ve protein düzeyleri eşit, sırasıyla 0, 20, 40, 60 ve 80 g/kg zeolit kapsayan 5 farklı karma ile yemlenmiştir. Araştırma, 28'er günlük periodlardan oluşan 4 dönem halinde sürdürülmüştür. Muameleri oluşturan 5 rasyon, kafes bloklarının her katında 4 kafes gözü tekerrürlü olmak üzere, 3 kata tam şansa bağlı olarak dağıtılmıştır. Araştırma sonuçlarına göre, canlı ağırlık, yem tüketimi, yemden yararlanma oranı, yumurta verimi, kabuk kalınlığı, yaşama gücü ve diğer yumurta kalite özellikleri bakımından, muameleler arasında farklılık bulunmamıştır (P>0.05). Dışkı nem içeriğinde ise özellikle clinoptilolitle yemlemeye bağlı olarak önemli düşüşler gözlenmiştir (P<0.05).

Introduction

Zeolites are crystalline, hydrated aluminosilicates of alkali (e.g. Na^+, K^+) and alkaline (e.g. Mg^{+2}, Ca^{+2}) earth cations, having infinite three–dimensional structures. They have the ability to gain and lose water reversibly and to exchange constituent ionic cations without major changes of structure (1, 2). Ca^{+2}, cations are exchangeable with other cations such as NH_4^+, Mg^{+2}, Na^+, K^+.

Although it has been reported that feeding laying hens with zeolite improves eggshell quality (3–11), the mechanisms of this beneficial effect are unknown (3, 5). There are various hypotheses concerning the function of zeolite. The calcium–exchange capacity of sodium alumino–silicate (SAS) is known to be greater than 7.0 meq/g (12). Various researchers have hypothesised that the beneficial effect of zeolite on shell quality may be related to its high affinity for calcium and its high ion–exchange capacity (3, 6, 13–15).

It has been well documented that high levels of dietary phosphorus (P) decrease eggshell quality (16–20).

Another hypothesis is that the aluminum content of zeolite may complex with P, and may reduce the availability of P (12, 20–26). This may result in slight improvements in shell quality (11, 13, 26–28).

Feeding low levels of dietary P is thought to reduce serum P and facilitates the utilisation of skeletal calcium in shell formation during the night (12, 29). Results presented by Roland and Laurent (5) show that dietary P levels have no influence on shell quality due to sodium zeolite A.

If the mechanism of zeolite involves aluminum, reducing the availability of P, the effect of zeolite on egg shell quality depends on dietary P. Thus, the lower the hen's intake of P, the less beneficial is the effect of SAS on shell quality and the greater the possibility that zeolite may have an adverse effect on egg production (12). Fethiere et al. (25) claimed that a decrease in feed intake, and thus a decrease in P intake in the presence of SAS, is directly related to poor hen performance, particularly when low levels of P are fed. However, Roland (12) showed that SAS improved the specific gravity of eggs and hypothesised that the mechanism by which SAS improves specific gravity is independent of P. There are contrasting views of the effect of P levels on hen performance. Several authors (13, 26–28) have reported that reducing dietary levels of P produces small improvements in shell quality. On the other hand, others (5, 30–32) have reported that reducing dietary P has no effect on specific gravity, which has led to uncertaintly concerning the effects of P on shell quality.

The effects of zeolite may be observed due to its high molecular sieve adsorption capacity; effective selectivities for cations and ion–exchange capacity; hydration and dehydration; deodorising properties; and acid resistance. These may play a role in explaining the effectiveness of natural zeolites in agriculture (33, 34).

Additionally, natural zeolites can adsorb excess ammonium levels and help to reduce the problem of subsequent ammonia generation (2). Beneficial effects may also be related to the Al, Si or Na content of zeolite because these minerals have been shown to influence Ca metabolism (6, 17, 23, 24, 35, 37).

There are conflicting reports in the literature of the effects of zeolite on egg yield and egg quality. The aim of this study, therefore, was to investigate the effects of zeolite on laying hen performance.

Material and Methods

A total of one hundred and eighty 37–week–old Babcock B–300 layers were used in this study. Hens with similar egg production capabilities and live weight were divided into 5 groups. They were put at random into 5 treatment groups (12 replicates and 36 hens per treatment). Before the experiment began, the hens were reared together in standard housing, management and nutritional conditions. At 37 weeks of age the hens were placed at random in wire cages (23x50x42 cm) in a naturally ventilated laying house and fed on one of the 5 different diets. They were fed commercial corn–soy–type diets containing five levels of natural zeolite (0, 2, 4, 6 and 8%). The composition of zeolite used in the experiment is shown in Table 1. In the first week 24h continuous lighting was used, which was decreased gradually until the 21st day, after which the hens were exposed to normal daylight. The hens were allowed ad–libitum access to feed and water. All diets, which were isocaloric and isonitrogenous, were fed for 16 weeks (Table 2).

The experiment was conducted in a three–tier cage system, with three birds in each cage. They were located in a deep pit house, ventilated both naturally and mechanically, and illuminated both artificially and naturally through windows.

All birds were individually weighed at the beginning of the experimental period and at 112 days of age. The feeds were weighed every 28 days to determine feed consumption and the feed efficiency ratio. Egg yields and mortality were recorded daily for each cage. Eggs produced by each group were collected and identified during the last three days of each week of every period. They were weighed together to determine the average egg weight of each group. Sevently–two eggs (two for each day) were taken to the laboratory and 10 of them were selected at random. They were broken and the following parameters were determined: Shell weight, shell thickness (using a micrometer) shell strength (by applying pressure on the pointed end of the egg with a screw–the force applied was measured in kilograms) the

Table 1. Composition of zeolite (clinoptilolite) used in the experiment*.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O %	K_2O	H_2O^-	Ti	Ag	Ni	B ppm
71.29	13.55	1.15	1.96	0.70	0.60	3.50	5.90	0.02	0.004	–	10

trace minerals, %

Co	0.004	Cr	0.002	Cu	0.002	Ga	0.004
Ge	0.004	Mn	0.01	Nb	0.004	Pb	0.002
Sn	0.002	V	0.004	In	0.004	Bi	0.002
Mo	0.004	Sc	0.004	Ce	0.4	La	0.01
Au	0.004	Cd	0.04	W	0.1	Zn	0.1
Yb	0.1	As	0.4	Ba	0.02	Si	0.04
Sb	0.04	P	1.0	Te	0.4	Ni	0.004
Li	0.1						

* Analysed at Mineral Research Institute (MTA–MAT)–Ankara.

Table 2. Compositions of the experimental diets.

Ingredients	Diets, % 1	2	3	4	5
Yellow corn	46.23	42.11	37.99	33.97	30.29
Soybean oil meal (44%CP)	21.69	22.46	23.24	23.91	24.50
Wheat	20.00	20.00	20.00	20.00	20.00
Meat–bone meal	3.00	3.00	3.00	3.00	3.00
Vegetable oil	0.52	1.88	3.23	4.59	5.92
Clinoptilolite	–	2.00	4.00	6.00	8.00
Vitamin–mineral premix[1]	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30
Dicalcium phospate	0.42	0.42	0.43	0.43	0.44
Ground limestone	7.48	7.46	7.44	7.72	7.18
DL–Methionine	0.10	0.10	0.11	0.11	0.11
ALBAC–% 15 ZINCB	0.01	0.01	0.01	0.01	0.01
Calculated composition					
ME, kcal/kg	2800	2800	2800	2800	2800
Protein, %	17.00	17.00	17.00	17.00	17.00
Lysine, %	0.84	0.84	0.85	0.85	0.85
Methionine, %	0.38	0.38	0.39	0.39	0.39
Methionine+cystine, %	0.68	0.68	0.68	0.68	0.70
Calcium, %	3.60	3.63	3.66	3.68	3.71
Available phosphorus, %	0.35	0.35	0.35	0.35	0.35

1 Containing the following, per kg of diet: Vitamin A, 10.000 IU; Vitamin D_3, 3.000 IU; Vitamin E, 25 mg; Vitamin K, 3 mg; Vitamin B_1, 1.5 mg; Vitamin B_2, 5.0 mg; Ca–D Pantothenate, 10 mg; Vitamin B_6, 3 mg; Vitamin B_{12}, 0.015 mg; Folic acid, 1 mg; Choline Chloride, 400 mg; D Biotin, 0.025 mg; Niacin, 30 mg; Carophyll red, 20 mg; Carophyll yellow, 5 mg; Manganese, 100 mg; Zinc, 60 mg; Iron, 40 mg; Copper, 5 mg; Cobalt, 0.5 mg; Iodine, 1 mg; Selenium, 0.2 mg.

albumen and yolk indexes, Haugh score (HS=100 log (albumen height + 7.57 – 1.7 x egg weight$^{0.37}$) and yolk color (using a Roche yolk color fan). The remaining eggs were kept in a refrigerator for 1 month; two eggs were broken weekly to determine whether discoloration or other quality changes would appear during storage. Egg production, feed consumption, feed efficiency ratio, egg weight, egg yolk index and albumen index, shell thickness, shell weight and yolk color values were determined for every 28 days.

Litter moisture samples were taken weekly from each cage. Droppings were collected 24 h a week on boards placed beneath each cage and their weight was recorded. The wet samples were dried in a convection oven at 105°C for 3 hours. The sample weights were determined and the moisture content calculated from the difference.

Data were statistically analysed using the ANOVA (factorial two–way variance analysis) procedure in the Statistical Analysis System, SAS, (38) and Duncan's New Multiple Range Test procedure in the SAS was used to identify significant differences between the mean values for each treatment.

Results

The body weight, body weight gain, feed intake, feed conversion ratio (FCR), faecal moisture content (FMC) and mortality rate are summarized in Table 3.

The effects of dietary zeolite on the various egg production characteristics are presented in Table 4.

Discussions

The results presented in Table 3 show that adding zeolites to the diets of layers from 259 to 371 days of age produced no significant differences in terms of live weight gain, feed consumption, feed efficiency ratio or mortality.

Table 3. Body weight, body weight gain, feed intake, feed conversion ratio (FCR), faecal moisture content (FMC) and percentage of mortality of hens fed on experimental diets*.

Dietary clinoptilolite content (g/kg)	Body weight (g/hen) starting	Body weight (g/hen) finishing	Body weight gain (g/hen)	Feed intake (g/hen/day)	FCR (kgfeed/kg egg)	FMC (%)	Mortality (%)
0	1452 a	1536 a	84 a	116 a	2.153 a	73.965 a	2.78 a
20	1452 a	1532 a	80 a	115 a	2.150 a	72.446 a	5.56 a
40	1450 a	1512 a	62 a	116 a	2.120 a	71.445 b	2.78 a
60	1457 a	1508 a	51 a	115 a	2.100 a	69.965 b	2.78 a
80	1461 a	1560 a	99 a	118 a	2.143 a	69.884 b	5.56 a

* Values within a column with different letters are statistically different (P<.05).

Table 4. Effect of natural zeolites on egg production, egg weight, shell weight, shell thickness, yolk ratio, albumen ratio, yolk index, albumen index, Haugh unit, yolk colour, shape index and shell strength.

Dietary clinoptilolite content (g/kg)	Egg production hen–day (%)	Egg yield (number)	Egg weight (g)	Shell weight (g)	Shell thickness (µ)	Yolk ratio (%)	Albumen ratio (%)	Yolk index (%)	Albumen index (%)	Haugh unit	Yolk colour	Shape index (%)	Shell strength (kg/cm^2)
0	90.2	100.4	60.8	5.91	375	26.58	58.87	42.61	6.28	74.46	9.7	79.33	3.32
20	87.5	97.9	61.1	5.82	374	26.72	58.45	42.84	6.29	74.19	10.0	79.00	3.38
40	91.0	101.8	61.0	5.80	375	26.55	57.55	42.15	6.28	73.77	9.3	78.33	3.34
60	90.8	101.4	61.9	5.84	376	26.64	58.36	42.56	6.29	73.98	9.0	78.33	3.31
80	91.2	102.1	61.8	5.80	377	26.57	58.05	42.12	6.30	73.97	9.3	78.33	3.41

These results are in agreement with the findings of Evans and Farrell (39), who concluded from several experiments that zeolites had no consistent beneficial effects (except faecal moisture content) when included in the diets of several layer strains in Australia. Similarly, the lack of response exhibited by body weight gain, feed consumption and feed conversion ratio with zeolite supplementation concurs with previous reports by Olver (7); Miles et al. (14); Roland et al. (29); Ballard and Edward (40); Rabon et al. (41); and Frost et al. (42), but it does not concur with some reports that zeolite improves performance in terms of the criteria mentioned above (20, 39, 43–46).

Dietary zeolites had no effect on egg quality according to the results of this study (Table 4). Data presented in Table 4 confirm the reports of Miles et al. (4); Olver (7); Roland (12); Elliot and Edwards (20); Roland et al. (29); Evans and Farrell (39); Rabon et al. (41); Frost et al. (42); Yalçın et al. (46); and Nakaue and Koelliker (47), who also found that production criteria were not affected by zeolites.

However, Olver (7, 44); Yalçın et al. (46); and Merabishvilli et al. (48) found that zeolites have a positive effect on egg production, while some others observed negative effects in terms of egg production (4, 6, 25, 29, 47), egg weight (4, 25), and feed consumption (4).

No effects of diet on mortality were detected in this study. These findings suggest that further research into clinoptilolite as a food additive is required (47). Nevertheless, Olver (44) reported that natural zeolites reduced colony counts in the gut microflora of the proximal and distal gut and described reduced mortality in broilers and layers.

The faecal moisture contents of the hens fed diets containing zeolite were lower than those of hens fed the diet without zeolite (P<.05). This may be due to the high water–absorbing capacity of clinoptilolite, producing drier droppings, less odour and thus fewer fly problems. This confirms the earlier findings of Olver (7, 44); Willis et al. (15); Nakaue and Koelliker (47); Onagi (49); and Palmer et al. (50). Willis et al. (15) indicated that zeolite–supplemented diets reduced faecal moisture by up to 25 percent.

Numerous reports indicate that zeolite improves the production characteristics of layers and broilers (7, 20, 39, 44, 48). The expected effects of zeolites may exhibit variation due to such factors as nature, concentration, the aluminum content of the zeolite and the level of Ca and P in the diet. However, both natural and synthetic zeolites contain approximately 10–15% aluminum (1, 20, 51). The aluminum content of the zeolite used in this study was 7.17% and the dietary aluminum contents were between zero and 0.57%. It should be taken into account that 0.15% dietary aluminum may be toxic to layer (52) and broiler chickens (20).

In conclusion, this study shows that dietary zeolite decreased only faecal moisture content but had no positive or negative effect on egg production and other performance criteria. It is suggested that zeolites may be included in the diet of laying hens at a level of 8% in populations with faecal moisture problems.

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