The effect of a clinoptilolite-based feed supplement on the performance of broiler chickens

P. Suchý[1], E. Straková[1], V. Večerek[1], Z. Klouda[1], E. Kráčmarová[2]

[1]University of Veterinary and Pharmaceutical Sciences, Brno, Czech Republic
[2]Centre for Hygiene of Food Chains Brno, Czech Republic

ABSTRACT: The main objective of this research was to verify the effect of feed mixtures supplemented with clinoptilolite-containing ZeoFeed (at a level of 1% and 2%) on the performance traits of broiler chickens in the period of their growth. Experimental results confirmed a positive effect of clinoptilolite on the performance of chickens which was demonstrated by a highly significant increase in the average live weight ($P \leq 0.01$) of broiler chickens at 40 days of age. The average live weight of broiler chickens was 2.24 kg (at a dose of 1%) and 2.28 kg (at a dose of 2%) with feed conversion of 1.84 kg (at a dose of 1%) and 1.95 kg (at a dose of 2%) while the average live weight of control broiler chickens was 2.12 kg with feed conversion of 1.83 kg. No differences between both groups were found in water consumption. Chickens in all monitored groups showed very good health and a very low rate of mortality (3.75% in control group, 1.25% at a dose of 1% and 3.75% at a dose of 2%). It follows from the experiments that the clinoptilolite-containing product may serve as a suitable feed supplement to feed mixtures for broiler chickens.

Keywords: feed additives; ZeoFeed; feeding of chickens; live weight; feed conversion; water consumption

The main aim of current developmental trends in the nutrition of farm animals is to produce a sufficient quantity of animal products and to ensure that produced raw materials will meet strict requirements for food safety. Feeds may contain a number of anti-nutritional substances which may enter food via animals and their products. Suitable procedures are therefore being sought to prevent the contamination of animals with these toxic substances and to control the subsequent penetration of these substances into the food chain. Feed additives also include a group of absorbents which can be used to cope with this problem, for example natural zeolites derived from clinoptilolites. Clinoptilolite is a mineral derived from hydrated aluminosilicate which contains ions such as Ca, K, Na, and Mg, and forms a 3D crystal lattice. This specific structure allows selective absorption of gases, ions and various low-molecular-weight substances such as mycotoxins. Clinoptilolites are able to selectively exchange their own ions for the ions from the environment (Boranic, 2000; Melenová et al., 2003). These substances were also found to absorb various mycotoxins (Parlat et al., 1999; Ortatatli and Oguz, 2001; Rizzi et al., 2003). Animals that were administered feed mixtures containing additives based on clinoptilolite showed better performance traits, for example, increased weight gain in pigs (Papaioannou et al., 2004) or increased laying and improved quality of eggs (Olver, 1997). Apart from the improved performance traits, these additives are also able to absorb ammonia, which is important with respect to the rearing of farm animals as it helps decrease ammonia levels in the stable environment (Meisinger et al., 2001; Melenová et al., 2003).

MATERIAL AND METHODS

The main aim of the presented paper was to examine changes in traits such as live weight, feed conversion, water consumption and health of broil-

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er chickens receiving feed mixtures supplemented with ZeoFeed.

An experiment was conducted on ROSS 308 hybrid broiler chickens of meat-type. A total of 240 one--day-old chickens (120 females and 120 males) were used in this experiment. The chickens were divided into 3 groups (control group C_1, experimental group E_1 1% and experimental group E_1 2%). Replications were parallel groups to each group (i.e. C_2, E_2 1% and E_2 2%). Chickens were kept till 40 days of age on deep litter in an accredited experimental enclosure of the Institute of Nutrition, Zoo-Technology and Zoo-Hygiene at the Faculty of Veterinary Hygiene and Ecology, University of Veterinary and Pharmaceutical Sciences in Brno, where controlled light, temperature, zoo-hygienic and feeding regimes were observed. Rearing conditions fully complied with rearing principles required for ROSS 308 broiler chickens that are described in the respective technological instructions for this kind of broiler chickens. Feeding and watering were provided by plastic tube feeders and Plasson MK II type hanging drinkers designed for poultry, which enable continuous measurements of water consumption. Chickens were fed *ad libitum* commercial complete feed mixtures designed for meat-type broiler chickens that were manufactured in the agricultural cooperative Hospodářské družstvo Hlučín specifically for this experiment. Broiler chickens were fed BR l mixture (loose form) till 11 days of age followed by BR 2 feed mixture (loose form) between days 12 and 30 and BR 3 mixture (loose form) from day 31 to day 40. All three groups of broiler chickens received identical commercial complete feed mixtures; the only difference was that the feed mixtures used in experimental groups E 1% – 1, E 1% – 2 contained ZeoFeed at a level of 1% and the feed mixtures used in experimental groups E 2% – 1, E 2% – 2 contained ZeoFeed at a level of 2%. ZeoFeed is a multifunctional feed additive containing clinoptilolite as the major component (min. 80%). The remaining 20% are different compounds such as Al_2O, CaO, MgO, Na_2O, and K_2O. The nutritional composition of feed mixture BR 1 (BR 2, BR 3) without ZeoFeed was as follows: dry matter – 887.54 g (888.46 g, 891.97 g), crude protein – 219.89 g (201.44 g, 187.40 g), lysine – 13.51 g (12.04 g, 10.82 g), methionine – 5.58 g (5.31 g, 4.95 g), threonine – 8.60 g (7.68 g, 7.82 g), tryptophan – 2.52 g (2.33 g, 2.20 g), arginine – 12.72 g (11.53 g, 10.89 g), fat – 31.97 g (38.81 g, 58.10 g), crude fibre – 26.26 g (26.29 g, 29.79 g), Ca – 9.53 g (9.02 g, 8.53 g), P – 6.50 g (6.21 g, 6.00 g), ME – 12.57 MJ (12.80 MJ, 12.89 MJ). Feed mixtures were supplemented with a premix containing minerals, vitamins and phytase (at a dose of 0.5%) designed for the feeding of broiler chickens and supplied by MIKROP Čebín; its composition was as follows: vitamin A 1 600 000 I.U., D_3 500 000 I.U., E 10 000 mg, K_3 300 mg, B_1 800 mg, B_6 600 mg, B_{12} 3 mg, biotin 30 mg, folic acid 500 mg, $FeSO_4.H_2O$ 10 000 mg, MnO 16 000 mg, ZnO 16 000 mg, $CuSO_4.5H_2O$ 1 700 mg, KI 200 mg. The ZeoFeed preparation in the concentration of 1% and 2% did not significantly affect the content of basic nutrients in feeds in experimental animals. Microclimatic parameters in the experimental enclosure were as follows: average daily air temperature ranged between 21 and 31°C depending on chickens' age, average daily relative humidity was 70–75%, light regime during the whole experiment was 24 hours of light.

The experiment included laboratory analyses of feed that were carried out at the Institute of Nutrition, Zoo-technology and Zoo-hygiene in order to determine the levels of nutrients, minerals and energy and verify the nutritional composition of the manufactured feed mixtures. The development of body weight was monitored by weighing broiler chickens at the age of 1, 12, 30 and 40 days. Parallelly to weighing, feed consumption and conversion were determined in the following time intervals: days 1–11, days 12–30, days 31–40 and days 1–40. Chickens' health was evaluated by examining clinical parameters such as vitality, feed intake, quality of droppings, and mortality rate.

The data on the body weight of chickens on day 1, 10, 20, 30, and 40 were processed by mathematical and statistical methods using the *t*-test implemented in the statistical programme UNISTAT that compared the calculated mean values. The results of the presented paper include the following statistical parameters: χ = arithmetic mean, SD = standard deviation, level of significance $P \leq 0.05^*$, $P \leq 0.01^{**}$, n.s. = not significant.

RESULTS

The addition of clinoptilolite-containing ZeoFeed into feed mixtures confirmed the positive effect of clinoptilolite on the performance of broiler chickens, as evaluated on the basis of weight gains during the experiment. It follows from Table 1 that the positive effect of ZeoFeed (1%) was seen for the

Table 1. Average live weight of broiler chickens during growth (Experiment 1)

Day 1	n	$\bar{x}$	SD	P
C_1	40	0.043	0.004	
E_1 1%	40	0.044	0.003	n.s.
E_1 2%	40	0.044	0.004	n.s.
Day 12				
C_1	40	0.29	0.029	
E_1 1%	39	0.29	0.042	n.s.
E_1 2%	39	0.29	0.044	n.s.
Day 30				
C_1	39	1.39	0.156	
E_1 1%	39	1.47	0.172	*
E_1 2%	38	1.41	0.175	n.s.
Day 40				
C_1	39	2.10	0.244	
E_1 1%	39	2.23	0.245	*
E_1 2%	38	2.27	0.337	*

n = number of chickens, $\bar{x}$ = arithmetical mean (kg), SD = standard deviation, P = level of significance $^*P \leq 0.05$, $^{**}P \leq 0.01$, n.s. = the significance of differences between average values (x) of experimental groups as compared with control

Table 2. Average live weight of broiler chickens during growth (Experiment 2)

Day 1	n	$\bar{x}$	SD	P
C_2	40	0.043	0.004	
E_2 1%	40	0.044	0.003	n.s.
E_2 2%	40	0.043	0.004	n.s.
Day 12				
C_2	38	0.27	0.042	
E_2 1%	40	0.29	0.038	n.s.
E_2 2%	40	0.27	0.038	n.s.
Day 30				
C_2	38	1.37	0.178	
E_2 1%	40	1.45	0.151	*
E_2 2%	39	1.42	0.149	n.s.
Day 40				
C_2	38	2.13	0.258	
E_2 1%	40	2.25	0.234	*
E_2 2%	39	2.28	0.192	**

n = number of chickens, $\bar{x}$ = arithmetical mean (kg), SD = standard deviation, P = level of significance $^*P \leq 0.05$, $^{**}P \leq 0.01$, n.s. = the significance of differences between average values (x) of experimental groups as compared with control

first time in chickens at 30 days of age, when experimental chickens in group E_1 1% – 1 had significantly higher ($P \leq 0.05$) average live weight (1.47 kg) in comparison with control group C_1 (1.39 kg). Both concentrations of ZeoFeed (1% in E_1 1% and 2% in E_1 2%) were demonstrated to have a positive effect on broiler chickens at 40 days of age. This positive effect was manifested by a significant increase ($P \leq 0.05$) in the average live weight of slaughter chickens (day 40) in group E_1 1% – 1 (2.23 kg) and E_1 2% – 1 (2.27 kg) in comparison with control C_1 (2.10 kg).

The results of the second experiment (i.e. the first experiment was repeated) were analogous, as documented in Table 2. This experiment also confirmed a significant increase ($P \leq 0.05$) in average live weight in group E_2 1% (1.45 kg) as compared with control C_2 (1.37 kg). Experimental broiler chickens at 40 days of age showed significantly higher live weight (2.25 kg in group E_2 1%, with ($P \leq 0.05$); 2.28 kg in group E_2 2% with ($P \leq 0.01$) in comparison with control chickens (2.13 kg) in group C_2.

When both experiments were combined and evaluated (Table 3), differences between the aver-

Table 3. Average live weight of broiler chickens during growth (total results of Experiment 1 and 2)

Day 1	n	$\bar{x}$	SD	P
C	80	0.043	0.004	
E 1%	80	0.044	0.003	n.s.
E 2%	80	0.044	0.004	n.s.
Day 12				
C	78	0.28	0.036	
E 1%	79	0.29	0.040	n.s.
E 2%	79	0.28	0.041	n.s.
Day 30				
C	77	1.38	0.167	
E 1%	79	1.46	0.162	**
E 2%	77	1.42	0.162	n.s.
Day 40				
C	77	2.12	0.251	
E 1%	79	2.24	0.240	**
E 2%	77	2.28	0.265	**

n = number of chickens, $\bar{x}$ = arithmetical mean (kg), SD = standard deviation, P = level of significance $^*P \leq 0.05$, $^{**}P \leq 0.01$, n.s. = the significance of differences between average values (x) of experimental groups as compared with control

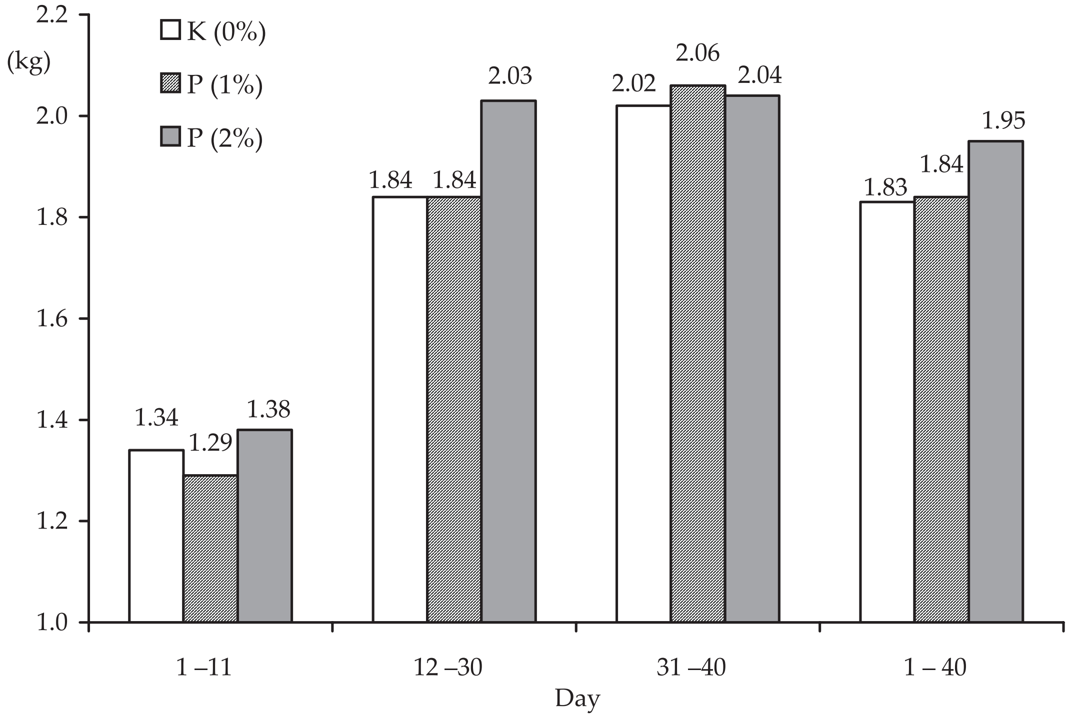

Figure 1. Conversion of feeding mixture (kg of feeding mixture/kg of live weight)

Table 4. Average consumption of drinking water per chicken in the particular groups on individual days during the experiment (ml)

Day	E 1%	E 2%	C	Day	E 1%	E 2%	C
1	25	25	42	21	149	158	170
2	29	28	36	22	177	172	180
3	35	34	42	23	167	172	181
4	44	42	38	24	175	175	165
5	50	48	52	25	178	159	164
6	54	51	56	26	198	213	207
7	62	58	69	27	189	194	194
8	70	68	77	28	203	208	214
9	66	65	71	29	210	217	228
10	88	81	89	30	211	220	233
11	87	86	94	31	218	214	229
12	86	91	88	32	215	239	248
13	94	88	90	33	264	269	281
14	106	99	101	34	285	287	287
15	103	104	119	35	293	295	284
16	124	120	122	36	329	333	324
17	131	125	124	37	327	312	307
18	129	131	130	38	328	329	343
19	142	139	137	39	353	360	358
20	140	139	157	$\bar{x}$	157	158	162

age values determined on day 30 and 40 were tested as significant ($P \leq 0.01$). The average live weight of broiler chickens in group E 1% on day 30 (1.46 kg) was significantly higher than that in the control group (1.38 kg). Similarly, average live weights of broiler chickens in group E 1% and E 2% on day 40 were 2.24 kg and 2.28 kg, respectively, which was significantly more than in control chickens C (2.12 kg).

One part of this study was focused on the monitoring of feed consumption per 1 kg of weight gain (i.e. conversion) in individual periods of the experiment, i.e. days 1–11, days 12–30, days 31–40 and over the whole experiment, i.e. between day 1 and day 40. The feed conversion is illustrated in Figure 1. It follows from the results that the feed conversion in control group C (1.83 kg) during feeding was the same as that in the experimental group E 1% (1.84 kg) while in group E 2% it was higher (1.95 kg).

The consumption of drinking water during the experiment was also monitored. It follows from Table 4 that water consumption increased gradually with chickens' age. The average daily consumption of drinking water per chicken (evaluated over the whole period) was 162 ml in control chickens (group C), 157 ml in group E 1% and 158 ml in group E 2%.

The chickens' health can also be evaluated positively. The chickens in all three groups that were included in the experiments showed no clinical signs of any disease. This fact was also confirmed by a mortality rate: out of the total number of 80 chickens only 3 chickens (3.75%) died in control group, 1 chicken (1.25%) in group E 1% and 3 chickens (3.75%) in group E 2%. Dissection revealed that heart failure was the most frequent cause of death in chickens that died in the course of the experiment.

DISCUSSION

The results confirmed that ZeoFeed administered at a dietary level of 1% and 2% had a beneficial effect on the weight gain of broiler chickens (Tables 1–3).

When administered to broiler chickens at a level of 1%, ZeoFeed resulted in an increase in live weight on day 30 of the experimental feeding. This finding was also confirmed in a repeated experiment. The major effect of this product at both levels of supplementation (1% and 2%) was detected in chickens at 40 days of age. This proved positive effect on weight gains in chickens during growth is in accordance with the findings reported by Papaioannou et al. (2004) concerning the effect of clinoptilolite on weight gains in pigs, and with the results of improved performance traits in chickens published by Olver (1997).

We concluded from the presented results that the effect of the feed additive manifested itself distinctly particularly in older chickens. The results of the experiment confirmed that the level of the feed additive might be increased with chickens' age. High doses of clinoptilolite (2%) in younger chickens (till day 30) may have a suppressive effect and reduce the performance of broiler chickens. This conclusion is also supported by the high feed conversion in experimental group E 2% (2.03 kg) in the period between days 12 and 30. At the end of the experiment, i.e. between days 31 and 40, the 2% level of the feed additive had no effect on feed conversion but showed a very beneficial effect on the weight gain in chickens. Another promising finding is that the feed additive tested at a level of 1% and 2% did not affect water consumption. Moreover, the enrichment of feed with the feed additive ZeoFeed had no negative effects on the chickens' health, as evaluated on the basis of the clinical state of animals, observed performance traits and mortality rate of chickens during feeding. Although the monitoring of ammonia concentration was not an object of this research, control measurements of ammonia levels revealed that the ammonia level in cages with experimental chickens was 30% lower than that in the control. This finding agrees with conclusions drawn on the basis of experiments performed by Meisinger et al. (2001) and Melenová et al. (2003), who pointed out the ability of clinoptilolite to bind ammonia, which resulted in decreasing levels of ammonia in the environment.

On the basis of our results the use of clinoptilolite-containing feed additives can be recommended. However, the dosage of the feed additive in feed mixtures has to be adjusted in respect to the chickens' age. When administered to chickens, feed additives of this type will increase the performance of chickens, decrease ammonia emissions, and enhance the safety of poultry meat.

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Corresponding Author

Prof. MVDr. Ing. Pavel Suchý, CSc., University of Veterinary and Pharmaceutical Sciences, Palackého 1/3, 612 42 Brno, Czech Republic
Tel. +420 541 562 670, fax +420 541 562 675, e-mail: suchyp@vfu.cz