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POSSIBILE USE OF NATURAL ZEOLITES IN ANIMAL PRODUCTION AND ENVIRONMENT PROTECTION

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Abstract

Natural zeolites contain micro- and macroelements such as calcium, magnesium, potassium, iron and copper. The aim of the following study has been to determine changes in poultry production induced by adding naturally occurring zeolites as dietary supplements. The study was carried out on 20,000 one-day chicks of the fattening breed called Ross. The birds were divided into two groups: the control group (group C) and the group supplemented with 5% of zeolite added to the feed (group E). Observations lasted for 45 days. Weekly measurements of the body weight of randomly chosen chicks were taken in both groups, and dead birds were counted. The composition of faeces was analyzed with an absorbance test. The air composition was determined with an instrument specially designed for that purpose. Differences in the body weight between groups C and E reached approximately 10%. A decrease in the mortality rate among chicks was observed in the treatment versus the control group. Mineral substances such as calcium and phosphorus were higher by about 4.4% and 9.5%, respectively, in the experimental group. Less ash in faeces (by about 20.4%) and less ammonia in the air (by about 33%) were determined for the experimental group, too. The present results may have important implications for poultry production, especially the fact that zeolite supplementation increased the body weight gain and reduced the number of falls. In conclusion, it is recommended to include zeolite in feed additives.

Keywords: natural zeolites, animal production, animals, environment protection, chickens.

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INTRODUCTION

Natural zeolites are aluminosilicates with skeletal structure, containing free spaces filled with large ions and water molecules, which can move raher easily and therefore facilitate ion exchange and reversible dehydration (Breck 1974, Mumpton, Fishman 1977). The skeletal structure of zeolite channels, different in the diameter, allows fast diffusion and exchange of water, ammonia, carbon dioxide, hydrogen sulphide and other gases in the aluminosilicate structures. This specific structure endows zeolites with several economically unique properties, such as:

1) adsorption – zeolites are highly efficient adsorbents of various compounds (gaseous mixtures, dilutions),
2) molecular-sieve function - each type of zeolite adsorbs molecules of a specific size, not exceeding the diameter of its channels,
3) cation-exchangeable property – cations weakly connected to the inner surface pores and channels may be subject to fast exchange with other cations,
4) catalytic property - the energy of active molecules in the pores of crystal sulphur in zeolites is reduced as a consequence of the ongoing reactions (Mumpton 1988, Mumpton, Fishman 1977).

The general formula of natural zeolites is as follows:

$$Me_{x/n}\,[Al_xSi_yO_2(x+y)]^* x^* z\,H_2O$$

where:

Me – metal,
n – degree of oxidation,
x – the number of aluminum atoms,
y – number of silicon atoms,
z – number of water molecules.

Among the large group of zeolitic minerals, lodes of clinoptiolite and modernite are arousing most interest. The widespread excavation of clinoptiolite lodes has led to their use in agriculture, construction industry, environmental protection and other areas of economy (Torii 1978).

Research has shown that zeolite given to piglets as a feed additive (2%) since weaning and throughout the fattening period caused a significant increase in weight gain and a noticeable increase in feed conversion (Breck 1974, Papaioannou et al. 2002*a*,*b*). Adding zeolite preparations to fodder inhibits ammonia emission from animal manure, thus improving the microclimate in a pigsty, which has a positive effect on the health of piglets. It has been documented that the concentration of ammonia decreased by 33%, while the concentration of carbon dioxide did not change significantly. Studies on the

use of natural zeolites in animal breeding have also covered poultry production. Zeolite in the form of granules 0.1-3 mm in diameter was used as a feed additive making up 3-6% of a feed ration.

An addition of 3-6% zeolite to a mixed feed ration has resulted in a higher body weight gain of chickens reared for fattening, better feed conversion ratio stronger hens' egg shells (CICISZWILI et al. 1990). Another reason why natural zeolites are used in animal production is their strong adsorption properties in relation to mycotoxins. While testing various sorbents have been applied to detoxify contaminated feed from mycotoxins, so far the best results have been achieved with the use of natural aluminosilicates (HUWING et al. 2001). It has also been shown that the prophylactic administration of aluminosilicates in animal feed can prevent aflatoxicosis (PHILIPS et al. 1990). Other studies on fattened chickens have shown that the addition of 1.5-2.5% of clinoptiolite to feeds protected the birds from harmful effects of aflatoxins (ORTATALI, OĞUZ 2001).

The aim of this study was to assess the benefits of using natural zeolites in the rearing of chickens for fattening, such as the ability of these mineral substances to adsorb aflatoxins as well as to improve the use of nutrients by chicks, accelerate their growth and reduce the mortality rate.

MATERIAL AND METHODS

No approval from the Local Ethics Committee on Animal Experimentation was required as the examined material was obtained posthumously and collected in a slaughterhouse. The blood used in the study was collected around the slaughter.

Animals and procedures

A preliminary assessment of the impact of zeolite on nutrient utilization and the mortality rate among chickens was carried out on 20,000 one-day chicks from the fattening breed Ross, which were kept in the same chicken coop. The birds were divided into two groups: the control group (group C) and the group supplemented with zeolites (group E). Each group contained 10 thousand chickens. The experimental group was given feed with an addition of 5% of zeolite, shredded to an average particle diameter of 1-3 mm. The chemical composition of the zeolite is specified in Table 1.

The observations lasted for 45 days. The body weight of randomly chosen chickens (n = 100) was measured at weekly intervals in both groups. Dead chicks were counted.

Table 1
Chemical composition of zeolites (%)

Chemical compound	(%)
Silicon oxide	69.43
Aluminium oxide	13.04
Iron superoxide	0.78
Iron oxide	1.05
Titanium oxide	0.18
Manganese oxide	0.033
Calcium oxide	2.10
Magnesium oxide	0.87
Phosphorus oxide	0.033
Potassium oxide	1.02
Sodium oxide	2.06
Fluorine	0.2-0.01
Arsenic	0.001-0.003
Antimony	> 0.012
Sulphur oxide	0.04
Water	1.03

Analysis of faeces

Faeces were collected randomly from 100 chickens in each group at the end of the experiment. A lump of faeces the size of a hazelnut was transferred to a flask, which was replenished with approximately 15 ml of distilled water. The contents were mixed with a glass rod until obtaining uniform consistency. The homogenate was filtered through a sieve (to remove any undissolved fragments of the stool sample). A predetermined amount of the homogenate was transferred into a centrifuge tube and rotated at 3000 rpm. The analysis was carried out by the absorbance test., i.e. some solution from the sediment was sampled and tested for its light coefficient (Zielinski 2000). Faeces of chickens fed with and without zeolite added to their feeds were put to the absorbance testing.

Analysis of the air composition

The composition of the air in the chicken house was determined separately for the experimental and control groups at the end of the experiment. The determinations were made with a special device for air compoistion determination called a GasHunter (Alter S.A. company, Tarnowo Podgórne, Poland).

Statistical analysis

All results are expressed as means ± SD (standard deviation). Differences between means were tested with the Student's *T*-test. Normal distribution of data was examined using the W. Shapiro-Wilk test and the equality of group variances was tested by the Brown-Forsythe test. If a lack of normal distribution and/or an unequal variance of data were detected, the Mann -Whithey *U*-test was applied. The *P*-value of less than 0.05 was considered statistically significant. All statistical analyses were carried out by Statistica 8.0 software (StatSoft, Inc. (2008). Statistica (data analysis software system), version 8.0. www.statsoft.com).

RESULTS

Production efficiency

The results of individual body weight measurements are comprised in Table 2. The body weight gain calculated for 45 days was 1.87 ± 370 g kg^{-1} and 2.08 ± 419 g kg^{-1} in the control group and supplemented with zeolites, respectively. On days 7, 28, 35, 42 and 45, the differences in body weight between groups C and E were approximately 10%.

Table 2

Body mass (g kg^{-1}) in individual measurements

Day	Control group (C)	Experimental group (E)
1	42.0 ± **5.2**	42.0±**5.2**
7	142.4±**9.35**	156.6± **10.55***
14	399.5±**10.0**	439.4±**13.02**
21	643.4±**10.68**	707.7±**14.35**
28	1214±**11.85**	1335±**14.9***
35	1682±**12.4**	1850±**15.2***
42	2229±**13.25**	2452±**16.0***
45	2558±**13.85**	2813±**16.25***

Data given are mean ±SD,
* indicates significant differences between the groups at $P < 0.05$

A decline in the mortality rate was noted among chickens supplemented with zeolite in comparison to the control group. At the end of the experiment, the number of deaths in group C was 63, while in group E it fell to 45.

Chemical composition of faeces

The chemical composition of faeces is shown in Table 3. The addition of natural zeolite to the broilers' diet increased nitrogen (about 6.5%) and gross energy (about 2.4%) in faeces. The content of mineral substances such as

Table 3

Chemical composition of faeces in the control and experimental groups

Specification	Control group (C)	Experimental group (E)
Fat	92.1± 0.35	93.6± 0.3
Nitrogen	33.6± 0.86	35.8± 0.1*
Starch	97.0± 0.3	97.7± 0.3
Gross energy	74.3± 0.1	76.1± 0.2*
Ash	32.9± 0.3	26.0± 0.45*
Ca	45.5± 0,15	47.5± 0.3*
P	21.02±0.25	23.02± 0.35*

Data given are mean ±SD,
* indicates significant differences between the groups at $P < 0.05$

calcium and phosphorus in faeces was higher, by about 4.4% and 9.5%, respectively. On the other hand, less ash (by about 20.4%) was determined in the experimental group's faeces.

Composition of the air in the chicken house

The level of air contamination is presented in Table 4. The reduction of ammonia in the air from the experimental housing area reached about 33%. In addition, a slight but not statistically significant decrease of carbon dioxide was observed.

Table 4

The air contamination in the chicken house for the control and experimental group

Indicator	Control group (C)	Experimental group (E)
CO_2(%)	0.16±0.02	0.14±0.03
NH_3 (ppm)	4.04±0.05	2.68±0.08*

Data given are mean ±SD,
* indicates significant differences between the groups at $P < 0.05$

DISCUSSION

According to many reports, natural zeolites used as feed additives improve feed utilization and increase weight gain of poultry. Although zeolites have been widely used in industries, animal husbandry and environmental protection, their effects in adequate animals models and possible medical applications await detailed studies. This article focuses on the beneficial effects on body gain and improved health status of young and adult chickens. In addition, it investigates the use of zeolites for better adsorption of nutrients such as microelements and macroelements.

Our results, like the findings of Mallek et al. (2012), showed that adding zeolites to diets of broilers increased weight gain. In contrast, Erner et al. (1998) and Incharoen et al. (2009) found that addition of zeolites to feed caused no significant differences in weight gain and feed consumption. According to Cabuk et al. (2004), supplementation of natural zeolite significantly reduced the body weight of broilers and also decreased the ammonia concentration of a broiler house. Machacek et al. (2010) observed that the addition of 2% clinoptilolite to a feed decreased daily feed consumption. On the other hand, 4% supplementation increased the consumption of a feed mix.

In their well-documented research, performed on 450 sows and their offspring, Papaioannou et al. (2002*a*) concluded that clinoptilolite supplement added to fodders throughout pregnancy and lactation had a positive impact on the health of sows and their offspring, improved the reproductive capacity of females and the productivity rate of piglets. There were no unwanted actions of the used zeolite.

Zeolites are potent surfactants characterized by high efficiency in the exchange of cationic and ionic elements (Bowman 2003). Thus, zeolites are very good sorbents, through which water passes well, and can therefore be used as sieve filters and sorbents in wastewater treatment. Zeolites are particularly useful for the removal of cations such as ammonium (NH_4) and certain heavy metals from water. Zeolites, especially clinoptilolites, are suitable for removing radioactive and cationic compounds (137Cs, 90Sr) from contaminated groundwater (Gunter et al. 2000).

Our results clearly show that feed containing added zeolites cause an increase of body gain of broilers, higher metabolic utilization of fat, nitrogen, starch, gross energy and reduced ash utilization. Zeolites also decreased the ammonia concentration in the air in the broiler house and reduced the number of falls.

Haiduti (1997) showed that the use of natural zeolites (1-5%) on soil contaminated by mercury significantly reduced the concentration of mercury in the shoots and roots of alfalfa (*Medicago sativa*) and grass (*Lolium perenne*). The well-proven property of zeolites to adsorb metal ions as a result of the cation exchange reaction has been used to remove toxic compounds of lead

from water. Research on the decontaminating action of zeolite in water bodies polluted by Pb $(NO_3)_2$ showed that the use of zeolites enhanced the health of fish (*Heteropneustes fossilis*) (Jain 1999). The above results implicate that natural zeolites can be widely used in decontamination of water bodies and soil (hence, plants and fish indirectly) when ecosystems are polluted with compounds of arsenic, mercury and lead. The most favourable effect in the removal of arsenic (arsenities and arsenates) from water achieved by using a variety of different natural zeolites was attributed to clinoptilolite (Elizalde-Gonzalez et al. 2001). Besides, addition of natural zeolites (5-10%) to bird droppings from industrial farms reduced the degree of salinity of this natural fertilizer (Turan 2008).

CONCLUSIONS

The present findings may have important implications in poultry production, especially the finding that zeolite increased body weight gain and reduced the number of falls. In conclusion, it is recommended to use zeolite in feed additives.

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