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The Use of Zeolite to Improve Housed Beef Cattle Performance by Reducing Ammonia Accumulation in Small Farm Conditions

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Abstract: The use of zeolite to reduce ammonia accumulation in housed beef cattle was investigated. Total forty one (41) local breed beef animals and Brown-Swiss crosses were kept under small-scale farm conditions. Animals were divided into two groups on the basis of weight as treatment with zeolite (ZE+) and without zeolite groups (ZE-) consisting of 20 and 21; with average 200 and 180 kg initial weights respectively. All cattle were fed *ad libitum* with straw and alfalfa hay supplemented with cereal-based concentrates. The animals receiving ZE+ and those with ZE- gained 128 and 90 kg weight and had 1.066 and 0.744 kg/day live weight gains respectively. There were significant differences ($p<0.05$) in total weight gain and daily live weight gain between the treatment groups. There was also 0.322 ± 0.121 kg difference in daily live weight gain in favor of treatment with ZE+. Zeolite can be used to reduce the ammonia accumulation in order to get rid of the discomfort created by the ammonia and to improve animal performance and welfare, resulting better quality animal production environment.

Key words: Zeolite, ammonia, beef cattle, performance

Introduction

There has been a major concern about the odor problem due to the ammonia accumulation in animal houses and farms in the developed countries and it is also receiving increasingly more attention in the developing countries. Ammonia (NH_3) is the major alkaline component of Earth's atmosphere.

Ammonia has a relatively short lifetime due to its rapid conversion to the ammonium (NH_4^+) radical and deposition of NH_3 to natural surfaces. Atmospheric NH_3 is produced by the decomposition of organic materials, biomass burning and fertilizer production and utilization (Arogo *et al*., 2001). Several factors are involved in ammonia release, both in barn and during storage and spreading of manure, e.g. temperature, ventilation rate and air speed above areas with manure, water content in manure, areas with exposed manure, storage time in the barn, type of manure, storage and spreading technique of manure and type of feeds and feeding routines (Frank *et al*., 2002).

In the last few decades livestock practices have evolved considerably. Highly integrated farms, notably in cattle, pig and poultry production have replaced by intensive systems using confined rearing methods (McCrory and Hobbs, 2001). Agricultural activities, livestock production in particular, have been reported to be the largest contributor of NH_3 emissions into the atmosphere. Farm animals consume a considerable amount of protein and other nitrogen (N) containing substances with their feed. The conversion of dietary N to animal product is relatively inefficient and 50 to 80% of the N consumed is excreted. Ammonia is then produced as consequence of bacterial activity involving the excreted organic N substrates.

In particular, ammonia that accumulates within animal housing systems can have a negative impact on animal health and consequently production. For example, reduced final body weights have been observed in poultry produced in houses with indoor ammonia levels of approximately 25 parts per million (ppm) or higher. Ammonia can also have a negative impact on human and animal health; exposure to ammonia can irritate the respiratory tract and eyes, even at low levels (Becker and Graves, 2004).

Many of the confined housing areas induce respiratory disease in animals. Inadequate ventilation leads to elevated humidity, increased concentration of pathogens and a build up of irritants such as dust, ammonia and other gases which affect not only animal health but also animal performance. In order to reduce the emissions of ammonia some dietary manipulations have been found useful such as using feed additives and reducing or controlling the protein level in the rations. Adding of Zeolite to animal slurry to reduce ammonia emissions have given notable results in the literature. Zeolite is a silicate clay mineral and a cation-exchange medium that has been used to reduce ammonia in water (Kithome *et al*.,1999) and in products such as kitty litter to reduce ammonia emissions from urine. Zeolite has been used as an amendment to poultry litter (Maurice *et al*., 1998), in anaerobic reactors treating cattle manure (Borja *et al*., 1996), during composting of poultry manure (Kithome *et al*., 1999) and as a filtration agent in deep-bedded cattle housing (Milan *et al*., 1997).

Therefore, in this study it is aimed to reduce ammonia accumulation and improve animal performance in housed beef cattle production in small scale farm conditions by using zeolite as a pre-excretion strategy since zeolite has gas and moisture adsorption features.

Materials and Methods

Animals

Predominantly local breed cattle and some Brown Swiss crosses for beef production purposes were used in the study and 41 animals in total were involved in this experiment. The experiment was lasted for 4 months from February to July, 2004 and conducted on the premises of two small farmer's barns with concrete floor. Animals were weighed using a mobile weighing bridge once every month. Body weights were recorded to the nearest kilogram (kg). Daily live weight gains (kg/day) were calculated as a performance parameter (Final weight minus Initial weight divided by the number of experimental days). The ammonia accumulation was not able to be recorded due to the financial and labour constraints.

Animals were divided into two groups and allocated to the barns on the basis of weight as treatment with zeolite (ZE+), consisting of 20 animals with average 200 kg initial weight and without zeolite groups (ZE-) consisting of 21 animals with average 180 kg initial weight. During the experimental period all cattle were fed with the same diets *ad libitum*, consisting of straw and alfalfa hay supplemented with sufficient cereal-based concentrates to sustain the feeding requirements of animals according to live weight change of animals and feeds were provided in such manner that feed always available in the feed bunks. Feed intakes were not able to be recorded as it needed extra labour.

Animal Housing

Two barns adjacent to each other with stalled concrete floor belonging to a small scale farmer were used for the experimental purposes. The dimensions of the barns were approximately 20 m length and 15 m width. Animals were accommodated on the two sides of the each barn. Each barn has 6 windows; 3 on each side close to the ceiling with the dimensions of 105×40 cm.

Table 1: Animal performance data of treatment groups with Zeolite and without Zeolite#

Treatments	Initial weight (kg)	Final weight (kg)	Total weight Gain (kg)	SE	DLWG (kg/day)	SE
ZE (+) n = 20	200	328	128[a]	4.85	1.066[a]	0.04
ZE (-) n = 21	180	270	90[b]	2.30	0.744[b]	0.02

[#] Means with the different superscript are significantly different ($p<0.05$)

Zeolite Application

Commercially obtained natural zeolite called clinptilolite (Enli Mining Corporation, Izmir, Turkey) was applied in granular form both sprinkling over the floor of the barns and mixing with the straw bedding about 3 kg m^{-2} and also hanging from the ceiling in a bag 200 mm mesh with holes containing 1/2 kg zeolite in amount. These applications were performed once a week and especially when bedding becomes wet and saturated.

Statistical Analysis

The data were statistically analysed by analysis of covariance in GLM (General Linear Model) to eliminate the initial weight differences and to determine the DLWG differences between treatment means by using the statistical software program Minitab for Windows v. 13 (Minitab, 2000).

Results

The results of animal performance data, initial, final weights and weight gains and the daily live weight gains (DLWG) of animals are given in Table 1. The experiment was conducted with minor health problems. Some animals from the ZE-treatment showed some signs of BRD (Bovine Respiratory Diseases) but did not affect the experiment.

The results indicated that the animals receiving ZE+ application and those with ZE-in the barn gained 128 and 90 kg weight and had 1.066 kg and 0.744 kg daily live weight gains respectively. There were significant differences ($p<0.05$) in total weight gain and DLWG between the treatment groups. There was also 0.322±0.121 kg difference in daily live weight gain in favor of treatment with ZE+.

Discussion

The observed health problems in animals with treatment ZE- might be associated with the higher concentrations of ammonia present in the facilities. As it was indicated by Lillie (1972) and Curtis (1983) at concentrations usually found in livestock facilities (<100 ppm), the primary impact of aerial ammonia is as an irritant of the eye and respiratory membranes and as a chronic stressor that can affect the course of infectious disease as well as directly influence the growth of healthy young animals.

Although it was not possible to measure the ammonia accumulation in this experiment a series of experiments at the University of Illinois measured the effects of various levels of aerial ammonia on young pigs. The rate of gain of young pigs was reduced by 12% during exposure to aerial ammonia at 50 ppm, but no lesions were observed in the respiratory system. At both 100 and 150 ppm aerial ammonia, rate of gain was reduced by 30% and tracheal epithelium and nasal turbinates showed lesions consistent with a tissue irritant (Drummond *et al*., 1980). Aerial ammonia at 50 and 75 ppm reduced the ability of healthy young pigs to clear bacteria from their lungs (Drummond *et al*., 1978). At 50 and 100 ppm, aerial ammonia exacerbated nasal turbinate lesions in young pigs infected with *Bordetella bronchiseptica,* but did not add to the infection-induced reduction in the pig's growth rate (Drummond *et al*., 1981a). In another study, 100 ppm aerial ammonia reduced the rate of gain by 32%;

while effects of 100 ppm ammonia and concurrent ascarid infection were additive to where the rate of gain was reduced by 61% (Drummond *et al*., 1981b). In a study of 28 swine farms in Sweden, a higher incidence of arthritis, porcine stress syndrome lesions and abscesses had a positive correlation with levels of aerial ammonia in the facilities (Donham, 1991).

The poor performance of animals with treatment ZE- might be also due to the type of housing, bedding, age of animals and other environmental factors as suggested by some workers that ammonia concentrations within cattle facilities varied greatly from 80 to 2001 mg/h per animal depending on the type of housing (concrete floors vs slatted flooring, ventilated vs closed), bedding, age of animals, environmental conditions, waste storage system employed, frequency of cleaning and ration (Koerkamp *et al*., 1998; Wathes *et al*., 1998; Pitcairn *et al*., 1998; Gurk *et al*., 1997).

The better performance of animals with treatment ZE+ can be attributed to the zeolite application. Since zeolites have special properties such as absorption of moisture (soak up like a sponge) and adsorption of gases (attract and keep gas molecules stuck to them). This means that ammonia, as well as other bad smelling gases, are trapped inside the zeolite to be harmlessly removed. Scoggins (1986) stated that measurable ammonia levels were significantly reduced when the zeolite was utilized. In addition there was an obvious lack of a detectable ammonia odor upon entering the barn or individual stall. Ammonia has great potential to produce damage to the respiratory tract. It may be one of the primary insults that result in severe respiratory disease in horses, especially foals and other young livestock. Zeolite traps both moisture and ammonia by tying them up. It was also reported that the ammonia and moisture absorbing qualities of zeolite are very effective in eliminating urine-generated odors of cattle, swine, poultry, sheep, lambs and other animals. Confined environments, such as feedlots, stockyards, holding/working pens, dairy barns, kennels, animal hospitals, rodeo/shows and other areas where odors are a problem are prime uses for zeolite.

The exact affects of ammonia accumulation on animal performance, live weight change and feed intake could have been estimated as amount of ammonia per animal. However, it can be concluded that natural zeolite actually removes ammonia and moisture through adsorption resulting in higher animal performance. The effective way to reduce ammonia release from confined cattle barns is to use restricted protein levels in rations supplemented with energy from easily digested carbohydrates.

Further studies, therefore, are needed for evaluation of the long term effects of zeolite application and low protein diets on ammonia release in animal houses and for the measurement of ammonia levels to determine its effects on animal performance (live weight change and feed intakes, feed conversion efficiency), health and welfare for better quality animal production environment.

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