

Relationship between Air Ammonia Concentrations and Bedding Hygiene in Dairy Cow Barns

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Abstract

The aim of this paper was the study of the relationship between the air ammonia concentration and the bedding hygiene in dairy cow barns with different housing systems. The study was conducted in 16 dairy farms (8 with tied stalls and 8 with loose housing) in Transylvania, in the cold season. In each farm, the airborne ammonia concentration was measured in the morning and the hygiene of the bedding was assessed. Air temperature, relative humidity and air flow velocity in the barns were determined simultaneously. The data were analyzed using the SPSS statistical software. The airborne ammonia concentration and the bedding hygiene score had significantly ($P > 0.05$) higher values in the barns with tie stalls. The ammonia concentration correlated positively with the bedding hygiene score in all the investigated farms. Keeping the bedding clean and dry in the dairy cows' barns is an important factor in reducing the airborne ammonia concentration.

Keywords: ammonia, bedding score, dairy cow

1. Introduction

Ammonia has been considered the most significant air pollutant in dairy cow barns. Prolonged exposure to ammonia can decrease cow immunity, increase morbidity and reduce milk production [1].

Several studies performed in different countries showed that ammonia concentrations in dairy cow barns vary greatly depending on the type of housing, livestock density, environmental conditions (air temperature, relative humidity, air

velocity), bedding, ventilation, frequency of cleaning and feeding ration [2, 3].

Generally, the average concentration of airborne ammonia in dairy buildings is below 10 ppm [2] and it tends to be slightly higher in barns where manure is deposited on solid floors. In most European countries, due to the irritating properties, the maximum admitted concentration of ammonia in the air of cow houses is 20 ppm [4], although other recommendations indicate only 10 ppm, considering the cumulative effects of harmful components [5]. In our country the maximal admitted value for ammonia in the air of cattle houses is 26 ppm [6].

In Romania only limited studies [7, 8] were published regarding the airborne ammonia concentration in dairy barns and the factors influencing it.

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The aim of this research was the study of the relationship between the air ammonia concentration and the bedding hygiene in dairy cow barns with different housing systems.

2. Materials and methods

The study was conducted in 16 dairy farms (8 with tied stalls and 8 with loose housing) in Transylvania, in the cold season. The farms were selected with the help of veterinarians from three counties of Transylvania and only those with the owners' agreement were included in the study. All the farms with tied housing system (THS) had closed barns, with natural ventilation. The manure cleaning was made by manual handling (in 80% of the barns) or mechanically (in 20% of the barns). The farms with loose housing system (LHS) had both closed (2 farms) and half-opened barns (6 farms). Most of the LHS farms (5 of 8 farms) used mechanical manure cleaning. The number of the cows varied in the assessed farms, housing between 30 and 90 cows/barn. In each farm, the airborne ammonia concentration was measured and the hygiene of the bedding was assessed. Air temperature, relative humidity and air flow velocity in the barns were determined simultaneously. The ammonia concentration was determined in the morning by air sampling with Dräger – Multiwarn II (Dräger Safety, Germany) device. Air temperature, relative humidity and air flow velocity in the barns were determined using a Testo 400 – GmbH & Co device. Bedding cleanliness was scored using the system of Panvivat et al. [9], scoring as follows: 1 = dry and clean; 2 = 20 to 40% of bedding surface dirty or wet; 3 = 40 to 60% of surface dirty or wet; 4 = 60 to 80% of surface dirty or wet; 5 = 80% of surface dirty or wet. The data were analyzed using the SPSS statistical software. The descriptive statistics included mean, standard deviation, median, minimum and maximum for each parameter. The data obtained were analyzed to determine the significance of the differences using the Mann-Whitney nonparametric test. Correlation coefficient (Spearman r) was used to test the relationships between ammonia concentrations and bedding score, relative humidity, air temperature and air flow velocity. The value of minimal significance was considered at $P < 0.05$.

3. Results and discussion

The results for the measured parameters in the 16 dairy farms are shown in Table 1.

In all the investigated farms airborne ammonia was found in various concentrations, significantly higher than in some other studies [2, 10, 11], but similar to those reported in Germany, Finland, Estonia and Romania [5, 7, 8]. Contrary to the results of other studies [12], the airborne ammonia concentration was found higher in the tie-stall farms than in the free-stall ones. This result could be because all the tie-stall barns were closed, and the free-stall barns were half-opened, facilitating better ventilation. Indeed, higher ammonia concentrations can be the result of limited barn ventilation [1]. In addition, in the majority of the barns in LHS the manure evacuation was done mechanically. The manuring interval and storage time in a dairy building influences the amount of exposed manure and the release of ammonia. Ammonia concentration and emissions can be reduced by removing manure before most of the ammonia has volatilized. The maximum admitted ammonia concentration was exceeded in 4 tie-stall barns. In all the barns with LHS the airborne ammonia, even if present, did not exceed the limit of 26 ppm.

The air temperature and relative humidity were significantly higher ($P < 0.05$) in the tie-stall barns than in the free-stall barns. The measured temperature had optimal values in the farms with THS, but in those with LHS it was slightly lower. Temperature is an environmental parameter that can affect the health, welfare, and production efficiency of dairy cows, and thus the profitability of dairy production. The relative humidity varied in the investigated farms, having much higher values in the tie-stall farms, and being optimal in the farms with LHS. In Romania, the recommended optimum relative humidity for dairy cows is from 60% to 75% [6]. Similar variation of relative humidity is reported by Teye et al. [5] in dairy cows' barns in Finland and Estonia. Relative humidity in the dairy buildings exceeded the recommended values when the ventilation was inadequate. High air humidity may have a negative impact on animal welfare and can promote bacterial development [13].

The velocity of the air flow had the same mean values in the farms with different housing systems, corresponding to those recommended for

dairy cows. The maximal recorded values in farms with THS and LHS were slightly higher. The

results are in conformity with those obtained by other researchers in their studies [5].

Table 1. Descriptive statistical analysis for parameters measured in the 16 investigated dairy cow barns

Parameter	THS (n=8)		LHS (n=8)	
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)
Ammonia (ppm)	26.13 (8.03)	28.50* (9.00 - 34.00)	15.63 (5.48)	14.00 (4.00 - 25.00)
Temperature (C°)	9.40 (2.58)	8.40* (6.00 - 14.20)	4.63 (1.30)	4.65 (3.20 - 7.40)
Relative humidity (%)	85.09 (6.22)	85.45* (74.60 - 93.00)	63.54 (6.55)	62.35 (57.00 - 78.80)
Air flow velocity (m/s)	0.35 (0.04)	0.34 (0.30 - 0.40)	0.30 (0.05)	0.31 (0.20 - 0.38)
Bedding score (1 to 5)	4.50 (1.07)	5.00* (2.00 - 5.00)	3.13 (1.13)	3.00 (2.00 - 5.00)

SD = standard deviation

THS = tie-stall housing system

LHS = loose housing system

* P < 0.05 the difference is significant between THS and LHS

The bedding score was significantly higher (P < 0.05) in the farms with THS than in those with LHS. To this result possibly contributed also the increased humidity in the barns with THS, besides the scarce hygiene of the bedding.

Correlation analysis revealed a significant relationship between bedding cleanliness score and ammonia concentration both in the farms with THS ($r_s = 0.76$, P < 0.05) and in those with LHS ($r_s = 0.88$, P < 0.01). Similar results are reported recently by Kaufman et al. [14] in dairy calf housing. No significant correlation (P > 0.05) was found between the airborne ammonia concentration and temperature, relative humidity or air flow velocity, probably because the reduced number of measurements in the investigated barns. These results are in accordance with those communicated in other studies [10, 14].

4. Conclusions

The results of the present study indicated a higher concentration of airborne ammonia in the closed barns with THS, which were dirty and had scarce ventilation. Keeping the bedding clean and dry in the dairy cows' barns is an important factor in reducing the airborne ammonia concentration.

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