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MICROCLIMATE PARAMETERS AND VENTILATION INSIDE THE BARNS IN THE LOWLAND REGION OF BOSNIA AND HERZEGOVINA

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ABSTRACT
Purpose of this paper is analysis of microclimate parameters in dairy cow barns in Bosnia and Herzegovina (Republic of Srpska), and examine the impact of the ventilation on the microclimate inside the barns. The study included 38 dairy barns in the lowland region of Bosnia and Herzegovina (Republic of Srpska), during the winter season. The following microclimate parameters were measured: air temperature, relative humidity of air, air velocity and concentration of gases (NH_3 and CO_2). Statistically significant correlations were determined between NH_3 concentration and air temperature ($P<0,001$) and between temperature and concentration of CO_2 ($P<0,05$). Also, are established positive and statistical significant correlation between manure gases (NH_3 and CO_2). The research has also shown that the average concentration of CO_2 in relation to the open area in the barn statistically significant ($P<0,05$).
Key words: dairy cow barns, microclimate parameters, ventilation

INTRODUCTION

Microclimate and ventilation is important factor that identify quality of air in livestock buildings. Particularly in terms of removing harmful gases and ensure thermal comfort and control environment by ventilation. Such ventilation affects indoor microclimate parameters and assists the maintenance of a comfortable environment for dairy cattle (Teye, 2008). In the barns is necessary to provide the optimal microclimatic conditions, because those have a major influence on health, welfare and production of dairy cows, and thus the profitability of dairy production.

In order to achieve better production results in modern cattle production, we must ensure optimal conditions for the animals. The key role in this has barn and microclimate conditions (Mijić, 2013). When it is about housing of dairy cattle in Bosnia and Herzegovina (Republic of Srpska), there are a big differences between the regions, breeders, traditional breeding of cattle, breeding methods and economic opportunities of producers to invest in the system of dairy cattle breeding (Erbez et al., 2015).

Therefore, the aim of this study was to determine the microclimate parameters in the barns and obtained results compare with standards or similar research, and determine the relationship between investigated microclimate parameters. Analysis of microclimate parameters in relation to the representation of open space on the side walls of the barns, which affect the quality of housing in the certain number of cattle barns in Bosnia and Herzegovina (Republic of Srpska) were analyzed.

MATERIAL AND METHODS

The research was conducted at 38 dairy cattle barns in the area of 10 municipalities in lowland region of Bosnia and Herzegovina (Republic of Srpska). The investigations were carried out in the period from December 5th, 2013 to March 15th, 2014, in the winter, because cows were kept tied in the barns during the cold season (pasturing in the rest of the year). Next microclimatic parameters were measured: air temperature, relative humidity of air, air velocity and concentration of gases (NH_3 and CO_2). The air temperature and relative humidity were measured using Thermo Anemometer PCE-423, temperature and air velocity measured by Anemometer PCE-AM82 and stable gases measured by IBRID MX6 device.

The calculation to define the percentage of open area to the total surface of barns, take the openings on the side walls of barns.

The descriptive statistical indicators were calculated (mean, standard deviation, standard error of arithmetic mean, coefficient of variation, minimum and maximum) for the measured parameters. The Pearson correlation coefficient (r) between parameters of microclimate were also calculated.

RESULTS AND DISCUSSION

The descriptive statistical analysis for investigated microclimate parameters are presented in table 1.

Tab.1. Average values and variability of microclimate conditions in the investigated dairy barns

Microclimatic parameters	$\overline{X}$	$S\bar{x}$	Sd	CV (%)	Variations	
					Min.	Max.
Temperature (°C)	11.18	0.53	3.32	29.7	3.1	17.5
Relative humidity (%)	76.22	1.45	8.94	11.72	57.1	92.9
Air flow velocity (m/s)	0.12	0.02	0.14	116.6	0.01	0.67
Ammonia (ppm)	1.39	0.12	0.74	53.23	0	3
Carbon dioxide (ppm)	871.57	53.69	330.75	37.94	390	1690

Air temperature in the barn ranged from 3.1 to 17.5°C, which means that the temperature was optimal for dairy cows. Relative humidity had a value of 57.1 to 92.9 %, with an average of 76.22 %. The relative humidity in dairy housing should not vary more than between 40 and 80 % (DIN 18910, 2004), while Hristov (2002) suggested that the optimum humidity for cows is 50 to 75 %. Average values of humidity were the optimum values, but maximal value of relative humidity exceeded the recommended values. In a study conducted by Popescu et al. (2010) in Transylvanian dairy barns, the relative humidity varied from 59.2 % to 98.65 %. The same authors state that high relative humidity during the cold seasons is a major problem in most of the dairy buildings, as well as the relative humidity in the dairy buildings exceeded the recommended values when the ventilation was inadequate. The air velocity had a mean value of 0.12 m/s, wasn't in accordance with the recommendation for dairy cattle barns. According to the EFSA recommendation air velocity in barns for cattle should be about 0.2 m/s in winter and 0.6 m/s in summer. The ammonia concentrations varied from 0 to 3 ppm. Average values of CO_2 were in the range of 390 to 1690 ppm, which indicates that these values were below the threshold limit value of 3000 ppm. In a study conducted by Teye et al. (2007) in dairy cows' barns in Finland and Estonia, the concentration of carbon dioxide was from 522 to 1678 ppm.

We also studied the correlations between the investigated parameters of microclimate. Statistical significant and positive correlation were demonstrated between the air temperature and the ammonia concentration (P<0.001), and between the temperature and carbon dioxide (P<0.05) (table 2).

Tab. 2. Results of correlation strenght examination between single investigated microclimate parameters

Microclimatic parameters	P value	Correlation coefficient	The strength of association
T (^oC) – RH (%)	0.077^{NS}	0.48	No
T (^oC) – V (m/s)	0.075^{NS}	0.5	No
T (^oC) - NH_3 (ppm)	0.550***	4.23	Strong
T (^oC) - CO_2(ppm)	0.355*	2.36	Weak
RH (%) – V (m/s)	-0.288^{NS}	1.92	No
RH (%) – NH_3 (ppm)	-0.038^{NS}	0.23	No
RH (%) – CO_2 (ppm)	0.217^{NS}	1.35	Very weak
V (m/s) – NH_3 (ppm)	0.241^{NS}	1.5	Very weak
V (m/s) – CO_2 (ppm)	0.208^{NS}	1.90	Very weak
NH_3 (ppm) - CO_2 (ppm)	0.435**	2.9	Medium

***P<0.001; **P<0.01; *P<0.05; ^{NS}P>0.05

T^o- temperature of the air; RH – relative humidity of the air; V-air flow velocity; NH_3 – ammonia concentration; CO_2- carbon dioxide concentration

It is to conclude that with increasing temperature of the air inside the barn, increases the concentrations of manure gases, in particular the ammonia. Wu et al. (2012) state that the concentration of ammonia in naturaly ventilated barns in mostly influenced by temperature and air movement. This fact is confirmed by the study conducted by Popescu et al. (2010), according to which there a significant correlation between the ammonia concentration and temperature, and air movement velocity inside the barn. Also, that supports the research of Herbut and Angrecka (2014) who observed a significant correlation between air temperature and ammonia concentration and this correlation was most noticeable in winter. According to Romaniuk and Mazur (2014) is established positive correlation between ammonia concentration and internal temperature.

Tab. 3. Analysis of variance microclimate parameters in relation to the representation of open space on the side walls of barns

Source of variation	**d.f.**	**SS**	**MS**	F_{exp}
The air temperature				
Treatments	4	16.13	4.03	0.32^{NS}
Error	33	404.47	12.25	
Relative humidity of the air				

Treatments Error	4 33	614.8 2426.4	153.70 73.53	2.09^{NS}
Air flow velocity				
Treatments Error	4 33	0.05 0.71	0.012 0.021	0.57^{NS}
Ammonia concentration				
Treatments Error	4 33	2.25 18.83	0.56 0.57	0.98^{NS}
Carbon dioxide concentration				
Treatments Error	4 33	1244028.33 2913076.93	311007.08 88275.05	3.52*

*P<0.05

Positive and statistical significant correlation ($P<0.05$) is established between manure gases (NH_3 and CO_2). According to Hristov (2002) when ventilation is inadequate, especially in the morning, high ammonia concentrations are accompanied by high concentrations of carbon dioxide in the air barns.
In table 3 is presented statistically significant difference between examined microclimate parameters, determined by analysis of variance and considered in relation to the various solutions natural ventilation of investigated barns.

Based on the analysis of variance, is confirmed that the concentration of carbon dioxide was significantly influenced by the representation of open space in relation to the total area of barns. Thereby, it was confirmed that insufficient ventilation air exchange inside the barn causes increased concentration of CO_2. Also, according to Mijić (2013) carbon dioxide can be used to assess the effectiveness of the ventilation system, as well as when the ventilation in the barn are insufficient or inadequate, are increased the concentration of harmful gases. The concentration of carbon dioxide depends on the type of building, ventilation system and livestock density. In summer the concentration of carbon dioxide is lower than in the winter due to opening windows and doors, and higher rates of ventilation (Hristov, 2002).

CONCLUSION

Based on the exposed results of the research can be concluded that the investigated barns have relatively favorable microclimate. Only is required to improve the natural ventilation of the existing barns in terms to provide sufficient circulation of fresh air.

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