

The Effect of Stable Microclimate on Milk Production of Dairy Cattle

Anna Šimková, Miloslav Šoch, Kateřina Švejdová, Luboš Záborský, Tomáš Frejlich, Anna Švarcová, Bohuslav Čermák

University of South Bohemia in České Budějovice, Faculty of Agriculture, Department of Animal husbandry sciences, 370 05, České Budějovice, Studentská 1668, Czech Republic

Abstract

In the experiment were detected changes of air temperature and relative humidity inside the free-stall barn. It is affecting the welfare of stabled dairy cows of two different groups according to the stage of lactation during the summer. The effects of microclimate individual parameters in the barn were assessed on the basis of the temperature-humidity index in relation to milk production. From the research, it was found that the animals are housed in suitable microclimate conditions barn were not subject to heat stress without major loss of milk production. The contribution includes information about the values of decrease or increase milk production, depending on the temperature-humidity index. It highlights the importance of determining the temperature-humidity index of stables. Temperature-humidity index can be a useful tool for determining of thermal stress in different sections of the barn. However, it would be appropriate this method of calculating the temperature-humidity index improved and supplemented with the other climatic factors.

Keywords: dairy cows, microclimate, milk production, temperature-humidity index

1. Introduction

The main function of stables for livestock is the protection of farm animals against different and adverse microclimate conditions and provides them with enough good conditions and good welfare to an extent sufficient to achieve profitability in terms of production. Such conditions can be achieved when suitable technological equipment of sheds that will be timely and accurately determining stable climatic conditions [1].

One of the biggest problems of modern stables is to maintain a suitable stable microclimate in terms of values of various physical factors. These include: air temperature and relative humidity [2]. Cattle generally tolerate better the low temperature than the high temperature

environment [3]. One reason is that cows are homoeothermic animals. This means that they can maintain a constant body temperature. Physiologically they are thus relatively independent of the temperature conditions of the surrounding environment. This argument is however only relative, since too high or too low temperatures can cause various health problems from hypothermia or hyperthermia. This can result in reduced feed intake and subsequently lower milk production [4].

Another significant indicator of suitable stable environment is relative humidity. The main source of humidity in stables are the animals themselves, the wet surface, water sources, wet and hot feed and humidity of outside air [5]. Seasonal and daily changes of relative humidity can be inhibited due to the production of heat and by means of evaporation from the skin of animals or through ventilation stable [6].

Temperature-humidity index includes the combination of effect of temperature and relative

* Corresponding author: Anna Šimková, 387 772 611, anna-simkova@seznam.cz

humidity. The index is widely used to describe the heat load and is a good indicator of stress temperature climatic conditions. The calculation of the temperature-humidity index describes, for example [7] where by using of the equation is achieved specific values, which express the current comfort, stress-related conditions or suffering. In this case, the animals are not able to maintain thermoregulatory mechanisms or normal body temperature [8].

The aim of this study was to investigate the influence of physical of microclimatic factors (air temperature and relative humidity) expressed by the value of THI index for milk production of Holstein dairy cattle during the summer.

2. Materials and methods

The attempt was carried out on a farm in the Central Region in the Czech Republic, farming the Holstein dairy cattle. This data was measured during the summer from July to September.

The animals were stabled in free-stall housing. Stable orientation is situated north-south with a ratio of construction 3:1. A thermally insulated part of the building is only a roof comb slot. In side profile of the stable there are rolling sails. Longitudinal profile of the stable is open. Inside the barn there is split lengthwise feeding corridor into two halves, each half is further divided into three sections. In the sections there are stalls placed in three rows.

The animals were divided into two groups. The first group consisted of cows and heifers from the second to two months after calving and the second group consisted of cows from fourth to fifth months after calving. Stable microclimate was measured using a data logger with sensors (datalogger COMET 3120). The values of air temperature and relative humidity were recorded at regular intervals throughout the whole experiment. The resulting measured values of air temperature and relative humidity were used for the calculation of THI index (temperature-humidity index) of formula by [7]:

$$THI = 0,8t_{db} + ((t_{db} - 14,4) * RH) / 100 + 46,4$$

Where:

t_{db} – temperature (°C)

RH – relative humidity (%)

The resulting values of THI index were analyzed using Microsoft Excel to graph with values of milk production, which were taken from farm records. At the same time minimum, maximum and average values of air temperature and relative humidity and the average values of the temperature-humidity index are shown in the Table 1.

3. Results and discussion

Minimum, maximum and average values of air temperature (°C) and relative humidity (%) together with the values of calculated temperature-humidity index (THI) are recorded in Table 1.

The upper critical temperature for Holstein cattle there is 25 to 26 °C [9]. It can be assumed during the period of high temperature, which were characterized by the maximum temperature of stable air 27.1 °C in the first group and 30 °C in the second group, may cause thermal stress. Average values of the air temperature during the experiment were between 20.9 and 22.1 °C. The minimum values of the air temperature had values of 13.3 and 13.7 °C.

The highest relative humidity was 83%. On average 72% and the minimum value of the relative of humidity during the experiment was 63%. From the measured values was calculated final values of THI index for both groups. THI average values were 52 ± 6.8 (Group 1) and 52 ± 6.3 (Group 2), which corresponded non-stress conditions.

According to [10] cows exposed to these microclimatic conditions and their values are not subject to thermal stress.

Also [11] and [12] reported that values of THI 70 and less are considered suitable and higher values THI 75-78 are considered already stressful.

Milk production is affected by heat stress when the values are higher than THI 72. We can therefore infer that according to Figure 1, comparison of THI index and average milk yield, the cows throughout the experiment were not exposed to levels THI index higher than 59 (refer to Figure 1, the date 25.07.). Despite the fact that there were higher temperatures, values of dairy production reached the highest values. The allegation is confirmed by [13] and [14], according to them the milk production is not

affected by heat stress when the main THI values range between 35 and 72.

Table 1. Environmental conditions during the experimental period

Parameters	Summer	
	1.group	2.group
Temperature, minimum (°C)	13.7	13.3
Temperature, maximum (°C)	27.1	30
Average temperature (°C)	20.9	22.1
Relative humidity, minimum (%)	63	63
Relative humidity, maximum (%)	83	83
Average relative humidity (%)	72	72
Average THI ¹	51.9	52

¹THI: temperature-humidity index

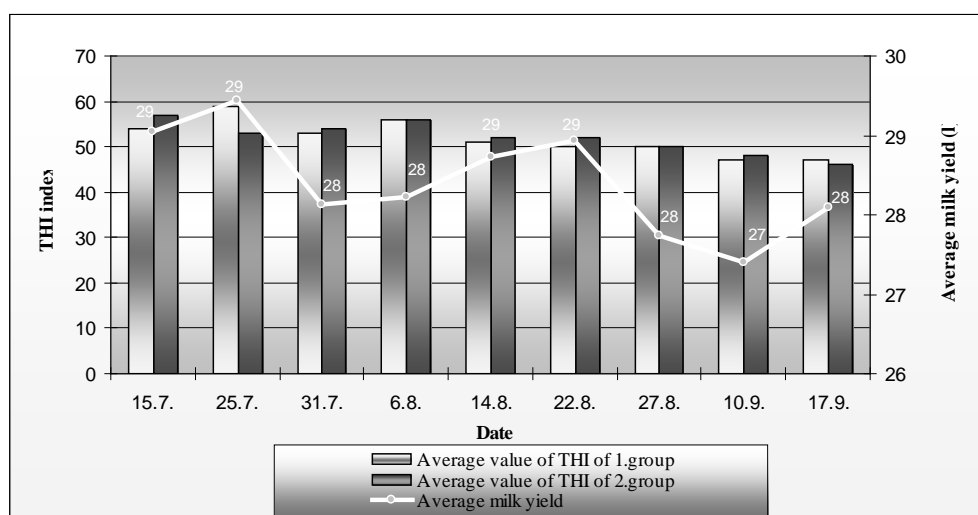


Figure 1. Comparison of THI index and average milk yield

4. Conclusions

On the basis of microclimatic values of air temperature and relative humidity, THI index was calculated using the equation. The obtained data indicate the course of the effect of air temperature and relative humidity on the milk production of dairy cows. Despite the fact that there was relatively high summer temperatures in the stable, values of THI index do not exceeded the critical values and moved throughout the experiment in the values that were not for the stabled animals stressful. Milk production in dependence on the growing THI index did not decline while the declining value of THI index did not increase milk production. Creating appropriate microclimatic conditions can be at elevated summer

temperatures to maintain milk production without large losses.

Acknowledgements

This article was written during realization of the project NAZV QJ1210144, NAZV QJ1210375 and GAJU 020/2013/Z.

References

- Marciniak, A.M., The use of temperature-humidity index (THI) to evaluate temperature-humidity conditions in free-stall barns, *Journal of Central European Agriculture*, 2014, 73-83
- Herbut, P., Angrecka, A., Forming of temperature-humidity index (THI) and milk production of cows in

- the free- stall barn during the period of summer heat, *Animal Science Papers and Reports*, 2012, 363-372
3. Illek, J., Kudrna, V., Matějček M., Novák, P., Slavík, P., Tepelný stres dojníc- zdraví, produkce, reprodukce, *Náš chov*, 2007, 63-65
 4. Bretenský, V., Mihina, Š., Organizácia a technológia chovu mliekového hovädzieho dobytká, Nitra, Slovenské centrum poľnohospodárskeho výskumu, 2006
 5. Novák, P., Kubíček, K., Fišer, A., Svoboda, J., Vegricht, J., Rizikové faktory stájového prostredia a jeho řešení, Praha, Ústav zemědělských a potravinářských informací, 1994
 6. Šoch, M., Basík, M., Novák, P., Vráblíková, J., Vliv relativní vlhkosti vzduchu a ochlazovací hodnoty prostředí na mléčnou produkci krav. *Functions of energy and water balances in bioclimatological systems*, 2003
 7. Hahn, G. L., Dynamic responses of cattle to thermal heat loads, *Journal of Animal Science*, 1999, 10-20
 8. Šoch, M., Vliv prostředí na vybrané ukazatele pohody skotu, České Budějovice, Jihočeská univerzita v Českých Budějovicích Zemědělská fakulta, 2005, pp. 288
 9. Berman, A., Folman, Y., Kaim, M., Mamen, M., Herz, Z., Wolfenson, D., Arieli, A., Graber, Y., Upper critical temperatures and forced ventilation effects for high yielding dairy cows in a subtropical climate, *Journal of Dairy Science*, 1985, 1488-1495
 10. Armstrong, D. V., Heat stress interaction with shade and cooling, *Journal of Dairy Science*, 1994, 2044 – 2050
 11. Erbez, M., Bøe, K. E., Falta, D., Chládek, G., Crowding of dairy cows in a cubicle barn during hot summer months, *Archiv Tierzucht*, 2012, 325-331
 12. Zejdová, P., Chládek, G., Falta, D., Vliv stájového prostředí na chování a mléčnou užitkovost dojníc, Mendlova univerzita v Brně, 2014, 10-13
 13. Johnson, H.D., Physiological responses and productivity of cattle, in: Yourself M.K. (Ed.), *Stress physiology in livestock, Basic principles*. CRC Press, Boca Raton, Florida, 1985, 4-19
 14. Du Preez, J.H., Giesecke, W.H., Hattingh, P.J., Heat stress in dairy cattle and other livestock under Southern African conditions, I. Temperature-humidity index mean values during the four main seasons, *Onderstepoort Journal of Veterinary Research*, 1990, 77-86.