Animal welfare, etológia és tartástechnológia

Animal welfare, ethology and housing systems

Volume 7 Issue 2

Gödöllő
2011

EFFECT OF STABLE CLIMATE ON MILK CONTENT AND TECHNOLOGICAL PROPERTIES OF BULK TANK SAMPLES IN CZECH PIED CATTLE

Falta Daniel, Polák Ondřej, Chládek Gustav

Mendel University, Faculty of Agronomy, Department of Animal Breeding, 613 00 Brno (CZ), Zemedelska 1
falta.daniel@mendelu.cz

Abstract

The aim of this research was to investigate the effect of stable climate on milk content and technological properties of bulk tank milk samples. It was analysed 29 weeks' samples on private farm in Říčany (3.6. – 16. 12. 2010). Milk originates from approx. 720 Czech Pied Cattle cows with average 7.500 kg/lactation. One day before taking samples average daily temperature and relative humidity were recorded. The bulk tank samples were analysed for average values of fat content (%), protein content (%), lactose (%), SNF - solids non fat (%), TA - titratable acidity (Soxhlet Henkel), RCT - rennet coagulation time (s) and quality of curd (class 1-5).

It was found that the minimal and maximal daily temperature resp. relative humidity changed in range -7.4–26.2 °C resp. 53.7–98.9 %. It means that in particular periods dairy cows were exposed to heat stress. In mentioned periods (when temperature was close to 26 °C) lower protein and fat content of milk was found and worse curd quality was frequently experienced although RCT was longer in colder period. Close correlation was confirmed between stable temperature and protein, fat resp. SNF content (r=-0.88, -0,85 resp. -0.84; P<0.01). Correlation coefficients of stable relative humidity with other parameters were contrary to those of stable temperature. Correlation between stable temperature and relative humidity was r=-0.66 (P<0.01). Other parameters were not affected by stable temperature or humidity.

Keywords: cows, milk production, stable temperature, relative humidity, heat stress

Introduction

The variation in milk yield within a species depends on many factors. Some of these factors are genetics, stage of lactation, daily variation, parity, type of diet, age udder health and season. The process ability and quality of milk products such as cheese, butter are influenced significantly by these factors, as well (*Ozrenk and Inci*, 2008). Dairy cow' s thermoneutral zone is defined as environmental air temperature range from 3 to 12 °C and heat (thermical) stress starts already from ≥25 °C. That is the reason why cattle are phylogenetically determined as arctic animal (*Hanuš et al*., 2008). *Vokřálová and Novák* (2005) presented that the termoneutral zone of dairy cows is in range -5 to 24 °C, whereas for high-yield cows the upper limit moved to 21 °C.

The average temperature of the Earth surface keeps increasing and the hot summer 2003 may have a bearing on global warming. The majority of farmers were not ready to cope with such situation, so it could bring significant economic losses. The number of days with extremely high temperatures, which substantially influence the performance of animals, is increasing, and this tendency will continue according to predictions (*Brouček*, 2006).

Hot weather has negative effects on animal performance and well-being. Reductions in feed intake, growth and efficiency are commonly reported in heat-stressed cattle. Impacts of heat load on these production factors are quite varied, ranging from little to no effect in a brief exposure, to death of vulnerable animals during an extreme heat event (*Brown-Brandl et al*., 2006).

The heat stress problem is getting worse as production levels continue to rise (*Mitlöhner et al*., 2002; *Beatty et al*., 2006). Summer depression of production causes significant economic loss in the dairy industry. Livestock performance is affected by heat stress because an animal having difficulty in losing heat will decrease its heat production by lowering feed intake, and it results in lower milk production. Generally, the more milk the cow produces, the greater the heat load produced from digestion and metabolism is (*Davis et al*., 2003; *Mader and Davis*, 2004). Heat stress occurs when the weather patterns change suddenly and the temperature increases rapidly, or temperature remains high for several consecutive days with little or no remission at night. A heat wave is a period of abnormally uncomfortable hot and unusually humid weather in duration of at least one day, but it conventionally lasts several days to several weeks (*A.M.S.*, 1989).

The reduction of milk protein contents during the hot summer months seems to be attributable to the reduction in casein content, specifically alpha-S and beta casein contents. Changes in casein contents and casein fractions might explain the alteration in cheese making properties of milk and the reduction in cheese yield during the summer in Italy. However, the main factor responsible for changing casein fractions during the summer was not identified (*Bernabucci et al*., 2002).

Material and methods

There were analysed 29 weeks' samples (3.6.–16.12.2010) on private farm in Říčany being located in a lowland area (49°12'32.314"North, 16°23'40.279"East). Milk originates from approx. 720 Czech Pied Cattle cows kept in identical conditions in loose housing stable with cubicles and fed ad libitum with TMR. Stable had no side walls or barrier and they are side-opened throughout the year (*Picture 1*). Cows were milked twice a day and average production was 7.500 kg/head/lactation.

The bulk tank samples were analysed for average values of fat content (%), protein content (%), lactose (%), SNF - solids non fat (%), TA - titratable acidity (Soxhlet Henkel), RCT - rennet coagulation time (s) and quality of curd (class). RCT was assessed by "Nephelo-turbidimetric sensor of milk coagulation" described by *Chládek and Čejna* (2005). Rennet „Laktochym" 1:5000 (Milcom Tábor) in amount 1 ml (attenuationed with distilled water 1:4) was used on 50 ml of milk. Quality of curd (50 ml) was evaluated after incubation period of 60 min in 35 °C according to scale (1-5) described by *Gajdůšek* (1999), where 1 is the best and 5 is the worst. Titratable acidity was assessed by standard ČSN 57 0530 item 58 (Soxhlet-Henkel). Milk protein, fat, lactose and solids non fat was provided by MilkoScope C5 Automatic (Scope Electric).

One day before taking morning bulk tank samples average daily temperature (°C) and relative humidity (%) were recorded in 15 min. intervals. These meteorological parameters were obtained by three data loggers (HOBO Onset) fixed at the height of cows' withers in the stable as representative conditions for milk production. For statistical process MS Excel and UNISTAT 5.1. programs were used.

***Picture 1:* Inner view of the loose housing stable in Říčany**

Results and discussion

Mean, minimum, maximum, standard deviation and variation coefficient of data from analysis of cows´ milk composition, technological properties, stable temperature and humidity are shown in *Table 1*. It can be seen that average daily temperature resp. humidity was 13.7 °C resp. 75.1 % (in range -7.4–26.2 °C resp. 53.7–98.9 %). It means that in particular periods dairy cows were exposed to heat stress (mainly when stable temperature was close to 26°C). Many authors (*Berman et al.,* 1985; *Hahn,* 1999 and *West,* 2003) reported that air temperature above 23-26 °C are critical for dairy cattle and causes reduction in milk production. However, *Falta et al*. (2008) proved average daily temperature of as low as 21 °C as a break-point for high-yield cows.

The content of fat resp. protein varied in range from 3.67 to 4.41 % resp. 3.33 to 3.83 %. The average fat content resp. protein content was 4.06 resp. 3.56 %, and these parameters showed the highest variability (4.73 resp. 4.65 %) of milk components. The average content of lactose was 4.7 % (in range from 4.62 to 4.86 %).

Table 1: **Basic statistical parameters of milk and stable climate**

	Units	Mean	Min.	Max.	Std.	Var. (%)
Protein	%	3.56	3.33	3.83	0.17	4.65
Fat	%	4.06	3.67	4.41	0.19	4.73
Lactose	%	4.78	4.62	4.86	0.05	1.12
SNF	%	8.96	8.77	9.24	0.15	1.72
TA	°SH	7.19	6.42	7.64	0.26	3.62
RCT	sec.	208	160	240	20.0	9.66
QC	class	1.62	1	2	0.49	29.9
Temp.	°C	13.7	-7.4	26.2	8.5	61.6
RH	%	75.1	53.7	98.9	10.8	14.4

SNF- solids non fat, **TA**- titratable acidity, **RCT**- rennet coagulation time, **QC**- quality of curd

The solids non fat was in range from 8.77 to 9.24 % and the average value was 8.96 %. The rennet coagulation time (RCT) was in interval from 160 to 240 second. We found the difference of 80 second between the best and the worst RCT. The average RCT for the entire period was 208 second. The quality of curd after incubation time of 60 min was mostly in 2nd class. Only in 11 cases the evaluation was in 1st class, especially in autumn period. The average titratable acidity was 7.19 ^{o}SH.

Table 2 showed the correlation coefficients between milk content, technological properties and stable climate.

Table 2: **Correlation coefficients between milk content, technological properties and stable climate**

	Protein	Fat	Lactose	SNF	TA	RCT	QC
Temperature (°C)	-0.88**	-0.85**	0.58**	-0.84**	-0.45*	-0.65**	0.17$^{N.S.}$
RH (%)	0.66**	0.71**	-0.44*	0.66**	0.24$^{N.S.}$	0.76**	0.14$^{N.S.}$

SNF- solids non fat, **TA**- titratable acidity, **RCT**- rennet coagulation time, **QC**- quality of curd
*P<0.05; **P<0.01; **N.S.** –non significant (P>0.05)

As for stable temperature the highest negative correlations were calculated with protein resp. fat content (r= -0.88 resp. -0.85; P<0.01). *Fig. 1* also represents the trend of increase protein and fat content by temperature decrease. *Ozrenk and Inci* (2008) also found that the protein and fat content of milk change along the year and milk protein percentage is positively correlated with milk fat percentage. *Kadzere et al.* (2001) proved that the protein percentage of milk decreased in all cows during the warmer period and temperature did not affect the lactose percentage. In addition, *Bernabucci et al.* (2002) said that milk yield during summer was 10 % lower than during spring, changing contrarily with milk components. Correlation between stable temperature and solids non fat was also very high (r=-0.84; P<0.01). Positive correlation was statistically proven only for lactose content (r=0.58; P<0.01).

RCT was negatively correlated with stable temperature (r=-0.65; P<0.01), which means when stable temperature raised, the time needed for coagulation was shorter as showed by *Fig. 2*. *Sevi et al.* (2001) confirmed that high ambient temperatures adversely affect the milk yield and cheese-making properties of milk by increasing the rennet coagulation time, the rate of curd formation and decreasing curd firmness. *Ikonen et al.* (2004) pointed that short time of coagulation is associated with higher content of protein and fat in milk.

Correlation coefficients of stable relative humidity with other parameters were contrary to those of stable temperature. Correlation between stable temperature and relative humidity was r=-0.66 (P<0.01).

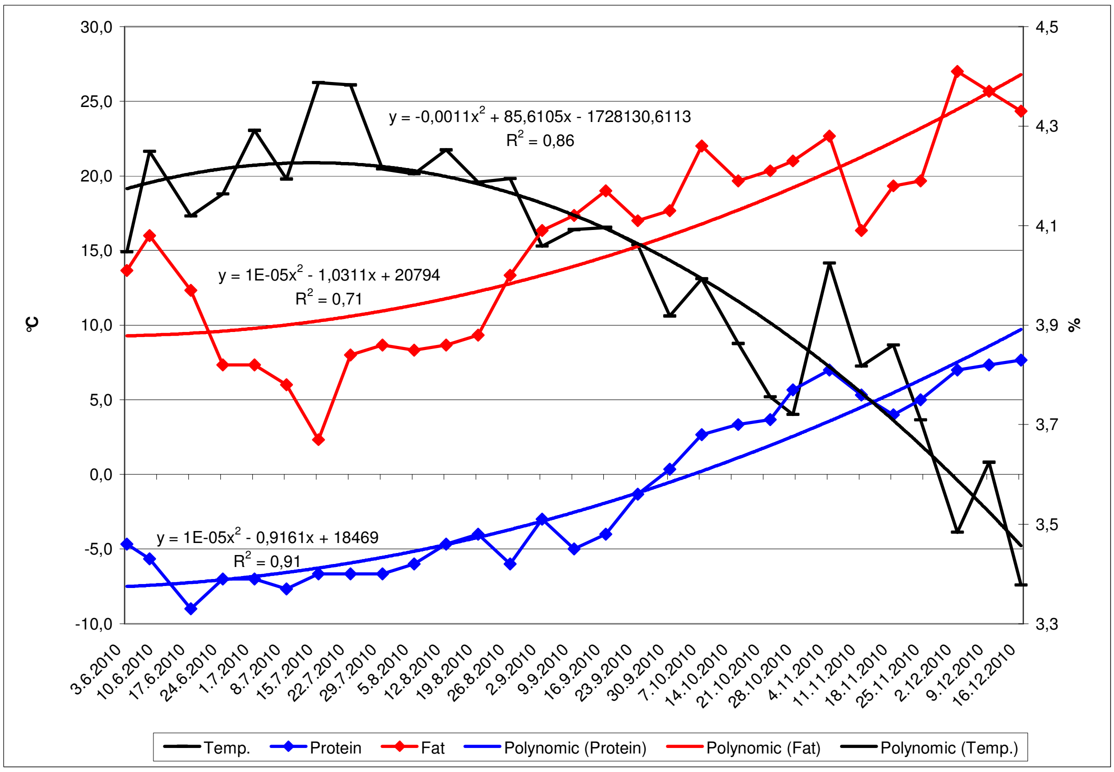

Fig. 1: **Impact of stable temperature on milk protein and fat content (P<0.01)**

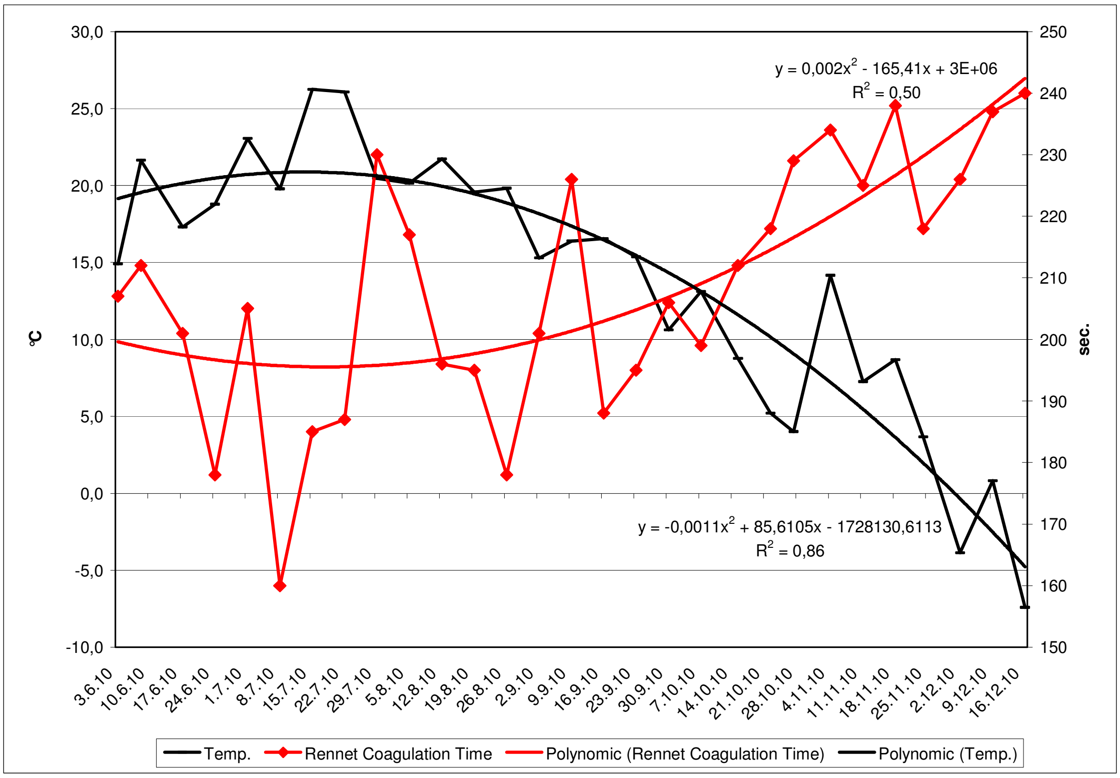

Fig. 2: **Impact of stable temperature on rennet coagulation time (P<0.01)**

Conclusions

It was determined that the amount of milk components was affected by stable climate. According to the results, it is possible to say that milk fat, protein and solids non fat percentages were the highest during the colder and the lowest during the warmer period. However, the lactose content had an opposite trend. As far as the technological properties is concerning the rennet coagulation time was shorter in warmer period as well as titratable acidity was lower. Stable relative humidity had opposite trend than temperature.

References

A.M.S. (1989): Glossary of Meteorology, 5th ed. American Meteorological Society, Boston, MA.

Beatty, D. T., Barnes, A., Taylor, E., Pethick, D., McCarthy, M., Maloney, S. K. (2006): Physiological responses of Bos taurus and Bos indicus cattle to prolonged, continuous heat and humidity. J. Anim. Sci., 84: 972-985.

Berman, A., Folman, Y., Kaim, M., Mamen, M., Herz, Z., Wolfenson, D., Arieli, A., Graber, Y. (1985): Upper critical temperatures and forced ventilation effects for high-yielding dairy cows in a subtropical climate. J. Dairy Sci., 68: 1488-1495.

Bernabucci, U., Lacetera, N., Ronchi, B., Nardone A. (2002): Hot season and milk protein fractions in Holstein cows. Anim. Res. 51: 25-33.

Brouček, J., Mihina, Š., Ryba, Š., Tongeľ, P., Kišac, P., Uhrinčať, M., Hanus, A. (2006): Effects of high air temperatures on milk efficiency in dairy cows. Czech J. Anim. Sci., 51 (3): 93-101.

Brown-Brandl, T. M., Eigenberg, R. A., Nienaber, J. A. (2006): Heat stress risk factors of feedlot heifers. Livestock Science, 105(1-3).

Davis, M. S., Mader, T. L., Holt, S. M., Parkhurst, A. M. (2003): Strategies to reduce feedlot cattle heat stress: Effects on tympanic temperature. J. Anim. Sci., 81: 649-661.

Falta, D., Walterová, L., Skýpala, M., Chládek, G. (2008): Effect of stable microclimate on milk production of Holstein cows on 2nd and 3rd lactation. [online], Animal welfare, etológia és tartástechnológia. 4 (2): 104-110.

Gajdůšek, S. (1999): Milk processing II –practise. Mendel University in Brno, (in czech), p. 92.

Hahn, G. L. (1999): Dynamic responses of cattle to thermal heat loads. J. Anim. Sci., 77: 10-20.

Hanuš, O., Vyletělová, M., Genčurová, V., Jedelská, R., Kopecký, J. Nezval, O. (2008): Hot stress of Holstein dairy cows as substantiv factor of milk composition. Scientia Agriculturae Bohemica, 39(4): 310-317.

Chládek, G., Čejna, V. (2005): Measuring of rennet coagulation time by Nephelo-turbidimetric sensor of milk coagulation. Mléko a sýry 2005, (in czech), Prague, p. 127-130.

Ikonen, T., Morri, S., Tyrisevä, A. M., Routtinen, O., Ojala, M. (2004): Genetic and phenotypic correlations between milk coagulation properties, milk production traits, somatic cell count, casein content and pH of milk. J. Dairy Sci., 87 :458-467.

Kadzere, C. T., Murphy, M. R., Silanikove, N., Maltz, E. (2001): Heat stress in lactating dairy cos: a review. Livestock Production Science, 77: 59-91.

Mader, T. L., Davis, M. S. (2004): Effect of management strategies on reducing heat stress of feedlot cattle: Feed water intake. J. Anim. Sci., 82: 3077-3087.

Mitlöhner, F. M., Galyean, M. L.,McGlone, J. J. (2002): Shade effects on performance, carcass traits, physiology, and behavior of heat-stressed feedlot heifers. J. Anim. Sci., 80: 2043-2050.

Ozrenk, E., Inci, S. S. (2008): The effect of seasonal variation on the composition o cow milk in Van Province. Pakistan Journal of Nutrition, 7 (1): 161-164.

Sevi, A., Annicchiarico, G., Albenzio, M., Taibi, L., Muscio, A., Dell´Aquila, S. (2001): Effects of solar radiation and feeding time on behavior, immune responses and production of lactating ewes under high ambient temperature. J. Dairy Sci., 84: 629-640.

Vokřálová, J., Novák, P. (2005): Climatic extrems and lactation. (in Czech), Náš chov, 9: 40-42.

West, J. W. (2003): Effects of Heat-Stress on Production in Dairy Cattle. J. Dairy Sci., 86: 2131-2144.

Acknowledgments

This study was subsidized by Research plan No. MSM6215648905 with title of “Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change“, which is financed by the Ministry of Education, Youth and Sports of the Czech Republic and internal grant of Mendel University IG TP 02/2010.