EFFECT OF BARN MICROCLIMATE ON MILK CONTENT AND TECHNOLOGICAL PROPERTIES OF BULK TANK SAMPLES IN CZECH FLECKVIEH COWS DURING THE WHOLE YEAR

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ABSTRACT

The aim of this research was to investigate the effect of barn microclimate on milk content and technological properties of bulk tank milk samples. It was analysed 53 week’s samples on private farm in Říčany (3.6.2010–2. 6.2011). Milk originates from approx. 700 Czech Fleckvieh cows with average 7.500 kg/lactation. One day before taking samples average barn airspace 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 (%), casein content (%), TA - titratable acidity (Soxhlet Henkel), RCT - rennet coagulation time (s) and CQC – curd quality class (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. 48.2–99.9%. 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 barn airspace temperature and protein, fat resp. SNF content ($r=-0.83$, -0.81, resp. -0.83; $P<0.01$). Correlation coefficients of stable relative humidity with other parameters were contrary to those of barn airspace temperature. Correlation between barn airspace temperature and relative humidity was $r=-0.55$ ($P<0.01$). Other parameters were not affected by barn airspace temperature or humidity.

Key words: cows, milk production, stable temperature, relative humidity, heat stress

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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 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 enviromental air temperature range from 3 to 12 °C and heat stress starts already from ≥25 °C. That is the reason why cattle are phylogenetically determined as arctic animal (Hanuš *et al*., 2008). According to Vokřálková and Novák (2005), the thermoneutral zone of dairy cows ranges from −5 to +24 °C.

Although the milk cattle shows a high adaptability to a wide scale of climatic conditions, its performance can be influenced by great temperature fluctuations occurring within the year. Nowadays, effects of the heat stress represents a tropical problem also in Eastern and Central Europe. Summer climate causes the heat stress of dairy cows and the heat stress results in am depression in milk production. The heat stress occurs in situations when the ambient temperature is higher than that of the animal´s thermal neutral zone (Novák *et al*., 2009).

The heat stress problem is getting worse as production levels continue to rise (Mitlöhner *et al*., 2002; Beatty *et al*., 2006). The summer depression in production of milk causes significant economical losses in the dairy industry. The basic condition of dairy farm management depends on the knowledge of and understanding to factors affecting milk production at most, i.e. not only nutrition and health status of dairy cows but also the parity and calving season, technological systems, and, above all, microclimatic conditions (Maust *et al*., 1972; Gader *et al*., 2007). Livestock performance is affected by heat stress mainly due to the fact that animals having problems with high temperatures and heat try to control their thermoregulation and heat production by reduced feed intake (Davis *et al*., 2003; Mader *et al*., 2004).

There is a negative correlation between the environmental temperature on the one hand and amounts of milk fat and protein on the other. When the temperature is increasing the solids non fat tends to decrease (Ozrenk and Inci, 2008). Ng-Kwai-Hang *et al.* (1984) and Lacroix *et al.* (1996) reported that the percentage of fat, protein and casein was influenced by the seasonal variations. Hanuš *et al*. (2008) observed influence of summer period on milk composition particularly on protein and solids non fat which decreased. Also Dolejš *et al.* (1996) mentioned a decrease in protein and solid non fat content in milk with increase of air temperature. It is clear that influence of dairy cow milk yield level on fat content (Hanuš *et al.*, 2007) is more intensive in Czech Fleckvieh but less intensive in Holstein (Janů *et al*., 2007) which is comparable to influence of environmental temperature variation on fat. Dolejš *et al*. (1996) found also the milk fat content depression with air temperature increase.

The aim of this study was to determine the effect of barn microclimate on content (i.e. contents of protein, fat, lactose, non fat solids and casein) and technological parameters (titratable acidity, rennetability and curd quality class) of bulk milk samples collected in herds of Czech Fleckvieh breeds of cattle during the whole year.

MATERIALS AND METHODS

The study was performed on private farm in the South Moravian Region of the Czech Republic within the period from June 3rd 2010 to June 2nd 2011. The herd on the private farm consisted only from purebred Czech Fleckvieh dairy cows (in average 700 head). In this herd, the average milk performance was 7,500 kg per lactation. The farm is situated in a lowland region in the village of Říčany, Moravia, Czech Republic (GPS 49°12'32.319"N, 16°23'42.666"E) in the altitude of 349 m. All animals were kept under identical conditions in a loose housing system with bedding and received also a complete feeding ration *ad libitum*. They were milked twice daily also at 4.00 and 16.00 h. This experiment took place in the same barn as that used by Erbez *et al*. (2010). On both farms were optimized diet according to Petrikovič and Sommer (2002). Feeding ration consisted from common used feeds in this region (corn silage, cereal meals, solvent oil meals, minerals and vitamins supplements).

Within a period of 53 weeks, bulk milk samples were collected in herd once a week. The samples represented a mixture of morning and evening milk. The average barn airspace temperature and relative humidity (BAT in °C and RH in %) were measured on the day before milk sampling. Temperature and relative humidity measurements were performed every 15 minutes using three HOBO data loggers (H08-007-02, Onset Computer Corporation®), which were located approx. 1.40 m above the floor level in three different locations inside the barn to eliminate the effect of only one place of measuring.

On the next day, the average percentages of fat content, protein, lactate monohydrate, solids non fat (SNF) and casein were estimated in collected bulk milk samples together with values of titratable acidity (TA), rennetability (RCT), and curd quality class (CQC).

Milk rennetability was estimated using a „Nephelometric-turbidimetric test of milk coagulation (Chládek and Čejna, 2005). The test was performed using the preparation Laktochym 1:5000 (Milcom Tábor) in the dose of 1 ml per 50 ml of milk (after the dilution of the renneting agent in the ratio 1:4). Curd quality (CQC) was evaluated after 60 minutes of incubation of 50 ml of renneted milk at 35 °C and compared with tabular values (Gajdůšek, 1999) using the scale from (1 = the best to 5 = the worst). TA was measured in a milk sample of 100 ml using an alkaline solution up to light pink colour of the mixture (in ml of the 0.25 $molx1^{-1}$ $NaOHx100ml^{-1}$). The method was performed pursuant provisions of the standard CSN57 0530. Contents of protein, fat and casein were estimated using the apparatus Milkoscope C5 (see the standard ČSN 57 0536).

For statistical analysis (by means of bi-factorial analysis of variance), programmes MS Excel and UNISTAT Version 5.1 were used.

The analyses carried on, including abbreviations and units of measurement were as follows:

Protein content	= (%), $g.100g^{-1}$
Fat content	= (%), $g.100g^{-1}$
Lactose content	= (%), $g.100g^{-1}$
Casein content	= (%), $g.100g^{-1}$
SNF	= solid non fat (%), $g.100g^{-1}$
BAT	= barn airspace temperature (°C)
RH	= relative humidity (%)
RCT	= rennet coagulation time (in seconds)
CQC	= curd quality class
TA	= titratable acidity (°SH).

RESULTS AND DISCUSSION

Mean, minimum, maximum, standard deviation and variation coefficient of data from analysis of cow´s milk content, technological properties, barn airspace temperature and humidity are shown in *Table* 1. It can be seen that average daily temperature resp. humidity was 10.87 °C resp. 76.09 % (in range -7.41−26.24 °C resp. 48.15−99.96 %). It means that in some periods dairy cows were exposed to heat stress (mainly when barn temperature was close to 26 °C). West (2003) recorded that air temperature above 23−26 °C are critical for dairy cattle and causes reduction in milk production. Other authors reminded that in high-yielding (i.e. > 6,500 kg) and, especially, older cows, the thermal stress developed at temperatures > 21°C (Novák *et al*., 2009; Vokřálková and Novák, 2005).

The content of protein resp. fat varied in range from 3.33 to 3.83 % resp. 3.67 to 4.41%. The average protein content resp. protein content was 3.57 resp. 4.07 %. The average content of lactose was 4.79 % (in range from 4.61 to 4.90 %). The average content of casein was 2.82 % (in range from 2.60 to 3.02 %).

Table 1: Basic statistical parametres of milk content and barn microclimate

	N	Mean	Min.	Max.	Std.
RCT	53	202.5	153.00	242.00	20.54
CQC	53	1.53	1.00	3.00	0.54
TA	53	7.08	3.51	7.72	0.58
Protein	53	3.57	3.33	3.83	0.15
Fat	53	4.07	3.67	4.41	0.21
Lactose	53	4.79	4.61	4.90	0.06
SNF	53	8.98	8.77	9.24	0.13
Casein	53	2.81	2.60	3.02	0.13
BAT	53	10.87	−7.41	26.24	8.95
RH	53	76.09	48.15	99.96	13.50

RCT – rennet coagulation time, **CQC** - curd quality class, **TA** – titratable acidity, **SNF** – solids non fat, **BAT** – barn airspace temperature, **RH** – relative humidity

The solids non fat was in range from 8.77 to 9.24 % and the average value was 8.98 %. The rennet coagulation time (RCT) was in interval from 153 to 242 second. We found the difference of 89 second between the best and the worst RCT. The average RCT for entire period was 202.5 second. The quality of curd after incubation time of 60 min was mostly in 2nd class. The average titratable acidity was 7.08 ^{o}SH.

Table 2 showed the correlation coefficients between milk content, technological properties and barn microclimate.

Table 2: Correlation coefficients between milk content, technological properties and barn microclimate.

	RCT	CQC	TA	Protein	Fat	Lactose	SNF	Casein
BAT (°C)	-0.39**	0.28*	-0.21	-0.83**	-0.81**	0.46**	-0.83**	-0.75**
RH (%)	0.46**	0.04	0.14	0.60**	0.67**	-0.50**	0.57**	0.55**

RCT – rennet coagulation time, **CQC** - curd quality class, **TA** – titratable acidity, **SNF** – solids non fat, **BAT** – barn airspace temperature, **RH** – relative humidity, *P<0.05; **P<0.01; N.S. – non significant (P>0.05)

As for barn airspace temperature the highest negative correlations were calculated with protein resp. SNF content (r= −0.83 resp. −0.83; P<0.01). *Fig.* 1 also represents the trend of increase protein and fat 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 of milk decreased in all cows during the warmer period and did not affect the lactose percentage. In addition, Bernabucci *et al.*

(2002) said that the milk yield during summer was 10 % lower than during spring, changing contralily with milk components with milk components. Correlation between air barn temperature and fat was also very high (r=−0.81; P<0.01). Positive correlation was statistically proven only for lactose content (r=0.46; P<0.01).

RCT was negatively correlated with air barn temperature (r=−0.39; P<0.01), which means when barn airspace temperature raised, the time needed for coagulation was shorter as showed by *Fig.* 2. This means that the higher the value of BAT, the shorter that of RCT. Average values of summer BAT indicated that during this season, the limit of heat stress could be trespassed on some days (Falta *et al.*, 2008; Hanuš *et al.*, 2008). As mentioned by Daviau *et al.* (2008), the shorter RCT was associated with a decrease in P content and also of casein. It was found out in this study that lower values of RCT were associated with a lower content of protein above all in the summer season; however, our results do not correspond with data published by Jõudu *et al.* (2008); Ikonnen *et al.* (2004) and Sevi *et al.* (2001) who obtained opposite results. This could be partly explained on the base of high summer temperatures recorded in our study.

Correlation coefficients of stable relative humidity with other parameters were contrary to those of barn airspace temperature. Correlation between barn airspace temperature and relative humidity was r=− 0.55 (P<0.01).

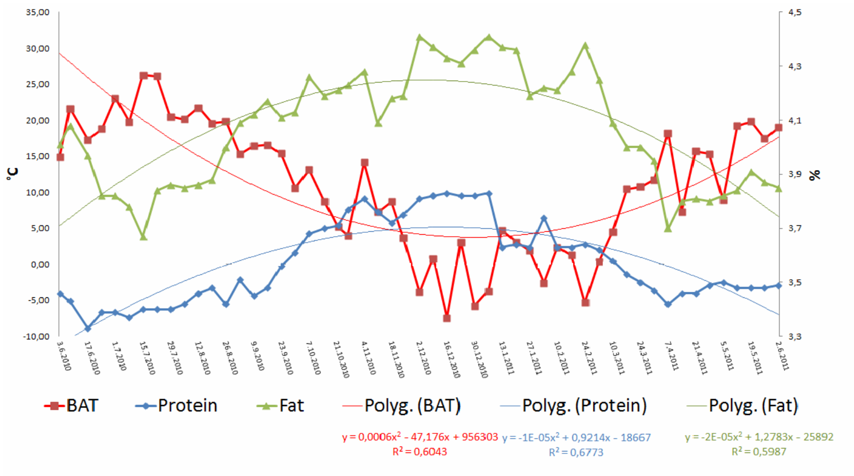

Fig. 1: Impact of barn airspace temperature on milk protein and fat content (P<0.01)

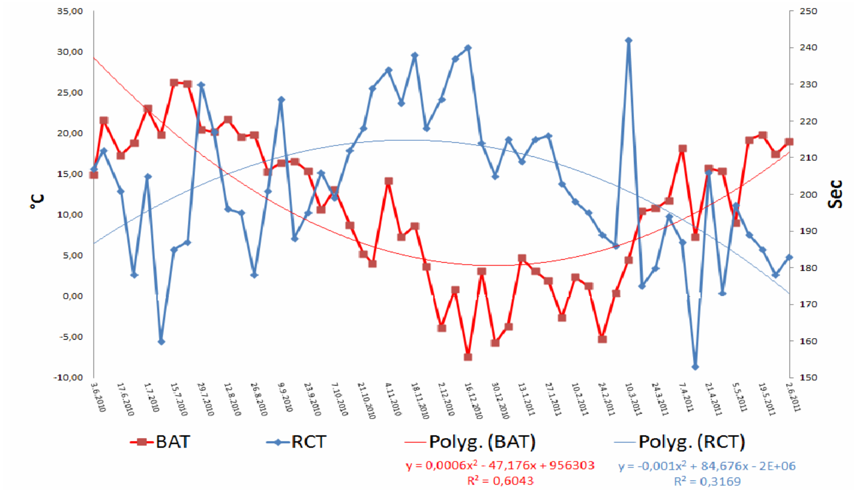

Fig. 2: Impact of barn airspace temperature on rennet coagulation time (P<0.01)

CONCLUSIONS

It was determined that the amount of milk components was affected by barn microclimate. According 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.

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