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EFFECT OF INCREASING TEMPERATURE AND CHANGES IN RELATIVE HUMIDITY ON COMPOSITION AND TECHNOLOGICAL PROPERTIES OF BULK MILK SAMPLES FROM CZECH FLECKVIEH BREED

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Abstract

Objective of this research was monitored effect of increasing temperature and changes in relative humidity on composition and technological properties of milk. During the period of 9.6.2013 to 21.6.2013 were analysed 13 bulk milk samples from morning milking (sampled daily) obtained in herd of Czech Fleckvieh cows from farm GenAGRO Říčany, a.s. (GPS 49°12'32.319"N, 16°23'42.666"E). Monitored climatic factors were follows: average diurnal temperature (ADT), relative humidity (RH). Monitored milk parameters were follows: content of fat, protein content, lactose content, solids-non-fat content, milk yield, specific density, active acidity, titratable acidity, freezing point of milk, rennet coagulation time and curd quality. It was also found that with increasing ADT statistically highly significantly ($P<0.01$) increases active acidity ($r = 0.80$) and rennet coagulation time ($r = 0.78$). Amount of milk fat was increasing very highly significantly ($r = 0.88$; $P<0.001$). With increasing ADT statistically significantly ($P<0.05$) decreases milk yield ($r = -0.65$) and specific density of milk ($r = -0.66$). Titratable acidity was decreasing statisticaly highly significantly ($r = -0.75$; $P<0.01$). It was not found statistically significant ($P>0.05$) difference between RH and other measured parameters.
Key words: Temperature, relative humidity, milk composition, technological properties, Czech Fleckvieh

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Abbreviation key: ADT – average diurnal temperature, F – milk fat, FP – freezing point, MY – milk yield, L – lactose, P – milk protein, pH – active acidity, CQ – curd quality, RCT – rennet coagulation time, RH – relative humidity, SD – specific density, SNF – solids-non-fat, TA – titratable acidity,

Introduction

Dairy cows are better adapted to conditions of low temperatures than high temperatures (*Knížková, Kunc,* 2006). Thermal comfort zone of cattle ranges from 10 to 16 °C (*Chládek*, 2004). With increasing milk yield of dairy cows increases the amount of produced heat (*Purwanto et al.*, 1990). In the case of heat stress is reduced feed intake, leading to a reduction of milk yield and changes in milk composition (*Kudrna et al.*, 2004). Dairy cows exposed to high

temperatures, often in conjunction with high relative humidity (RH) or direct sunlight usually respond to reduction of milk production (*Her et al.*, 1988). The main source of humidity in the stable are animals themselves, as well as wet areas and water resources. The amount of evaporation depends mainly on the temperature, the degree of saturation of water vapor and air flow (*Šoch et al.*, 2003). *Dolejš et al.* (1994) indicate the optimal RH for all categories of cattle from 50 to 70% for dairy cows in free stall barn a maximum value of RH 85 %. According to *Kadzere et al.* (2002) is already RH 65% risk for the development of heat stress. The most important climatic factors for the assessment of animal welfare are temperature and relative humidity (*West*, 2003; *Zimbelman et al.*, 2009).

Milk composition, as well as the technological properties of milk is influenced by many factors. It depends on climatic conditions, as well as other effects associated with individuality of dairy cows, nutrition, stage of lactation and others (*Doležal et al.,* 2000). In the Czech Republic was in the years 2011 and 2012 found that dairy cows of Czech Fleckvieh breed reached average milk yield 6766 kg per lactation with 4% of fat and 3.49% of protein (*Anonym*, 2012).

Material and methods

During the period of 9.6.2013 to 21.6.2013 were analysed 13 bulk milk samples from morning milking (sampled daily) obtained in herd of Czech Fleckvieh cows from farm GenAGRO Říčany, a.s. with free stall barn (GPS 49°12’32.319”N, 16°23’42.666”E). This period was chosen with regard to the rising average diurnal temperature in stable. Cows were fed total mixed ration ad libitum and were in various stage of lactation.

Analysis of samples was performed in the laboratory of Department of Animal Breeding at Mendel University in Brno. Content of milk protein (P), milk fat (F), lactose (L), solids-non-fat (SNF) and specific density (SD) was measured on instrument Julie C5 Automatic (Scope Electric) working on the principle of thermo analysis. Active acidity (pH) was measured by a pH meter CyberScan 510. Titratable acidity (TA) was detected by the methodology Soxhlet-Henkel titration of the sample with sodium hydroxide. Freezing point (FP) of milk was measured using an automatic cryoscope Cryostar 1 (Funke Gerber). Rennet coagulation time (RCT) was measured using nefelo-turbidic sensor of milk coagulation according to the methodology of *Přibyla and Čejna* (2006). Curd quality (CQ) was measured after incubation of milk with rennet according *Gajdůšek* (1997) and then placed in classes from 1 to 5. Lower number means higher quality. Milk yield (MY) from morning milking were recorded using a program Fastos 2000. Average diurnal temperature (ADT) and relative humidity (RH) represent the arithmetic mean of the temperatures in the control days, measured every 15 minutes using 3 sensors with HOBO data logger (Onset Computer). For statistical analysis were used programs MS Office Excel 2003 and STATISTICA 10.

Results and discussion

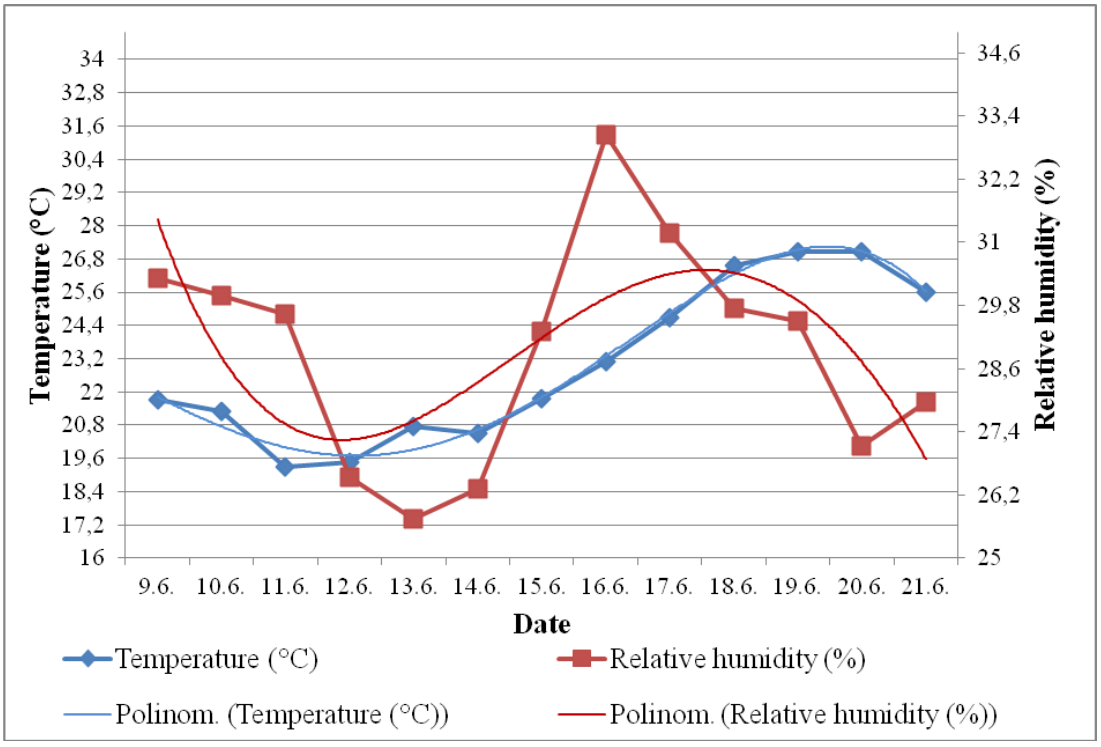
Table 1 illustrates average values of the measured parameters. Average ADT in monitored period was 22.99 °C, with minimum value 19.30 °C a maximum value 27.08 °C. Opinions on the border of thermal comfort and stress are different. *Dolejš et al.* (2002) states that dairy cows are not in thermal comfort zone at temperatures above 16 °C. *Chládek* (2004) considered temperature in thermal comfort zone to 16 °C. On the other hand *Roenfeld* (1998) indicates thermoneutral zone temperature between 5 ° C to 25 ° C. Average RH was measured 28.96% with the minimum value 25.75% and the maximum value 33.05%. *Novák et al.* (1996) states that too dry air (RH

below 35%) have a negative effect on dairy cows (dries the mucous membranes of respiratory tubes and reduces the effect of anti-infective natural barriers). *Figure 1* shows the relationship between ADT and RH during monitored period.

***Table 1*: Average value of the measured parameters (n=13)**

	Unit	$\overline{x}$	Min.	Max.	S_x
ADT	°C	22.99	19.30	27.08	2.88
RH	%	28.96	25.75	33.05	2.11
P	%	3.20	3.13	3.29	0.05
F	%	3.93	3.12	4.44	0.43
L	%	4.77	4.68	4.91	0.06
SD	$kg.l^{-1}$	1.0295	1.0286	1.0309	0.0007
SNF	%	8.69	8.53	8.94	0.12
pH	-	6.67	6.57	6.76	0.06
TA	°SH	6.02	5.50	6.44	0.28
FP	°C	-0.526	-0.529	-0.524	0.002
RCT	sec	217	195	241	16.38
CQ	class	2	1	3	0.60
MY	kg	7405	6485	7858	399.29

***Figure 1*: Relationship between ADT and RH during monitored period**



Average values of the measured parameters are shown in *table 1*. *Table 2* illustrates relationship between climatic parameters (ADT and RH) and milk parameters. Average MY per monitored period was detected 7405 kg with minimum value 6485 kg and maximum value 7858 kg. For MY and ADT was calculated correlation coefficient r = -0.65, which was evaluated as tight, statistically significant (P<0.05) relationship, meaning that with increasing ADT decreases MY. With this conclusion agree *Novák, Rožnovský* (2008), *Zejdová* (2012) found slightly tight correlation relationship r = -0.207. Average content of F was measured 3.93%, with minimum value 3.12% and maximum value 4.44%. For the content of F and ADT was found correlation coefficient r = -0.88, indicating a very tight, very highly statistically significant (P<0.001) relationship. This result is in contrast to the results of many authors. *Drevjany et al*. (2004) and *Javorová* (2012) found that high temperatures have a negative influence on the content of F, while the low temperature causes an increase in the content of F. *Doležal, Abramson* (2009) and *Gajdůšek* (2003) add that this decrease has resulted the heat stress. Average pH value was found 6.67 with minimum value 6.57 and maximum value 6.76. In the relationship of ADT and pH was statistically highly significant difference (P<0.01) and tight correlation relationship r = 0.80. Average value of TA was detected 6.02 °SH. The lowest measured value was 5.50 °SH, the highest 6.44 °SH. Between TA and ADT was found statistically highly significant difference (P<0.01) with a correlation coefficient r = -0.75. *Polák et al.* (2011) found not statistically significant relationship (P>0.05). Average value of RCT during monitored period was 217 sec. Minimum value was measured 195 sec and maximal value was 241 sec. Between RCT and ADT was found statistically highly significant difference (P<0.01) with a correlation coefficient r = 0.78, indicating a close dependence. On the contrary *Polák et al.* (2011) found in they research correlation coefficient r = -0.39 (P<0.01). *Čejna, Chládek* (2006) states that the milk with faster RCT have more favorable properties for cheese making. Among ADT compared with all other measured parameters (content of P, L, SNF, FP and CQ) were not found statistically significant differences (P>0.05).

Among RH and all measured parameters were not found statistically significant differences (P>0.05). *Falta et al.* (2011), however, in his research reached the statistical difference between RH and milk composition (P, F, L). According to *Polák et al.* (2010) RH does not affect on milk composition and technological properties. Results of *Zejdová* (2012) showed a negative correlation between MY and RH r = -0.49. *Falta et al.* (2009) states that the effect of RH on MY is very low (r = -0.06).

***Table 2*: Relationship between climatic parameters (ADT and RH) and milk parameters**

	P	F	L	SD	SNF	pH	TA	FP	RCT	CQ	MY
ADT	-0.35	0.88***	-0.31	-0.66*	-0.29	0.80**	-0.75**	-0.40	0.78**	0.36	-0.65*
RH	0.14	0.05	0.12	0.06	0.13	-0.01	-0.06	-0.05	0.23	-0.02	0.31

*= P<0.05, **= P<0.01, ***= P<0.001

Conclusions

Based on the analysis of the effect of rising temperature in the barn and changes in relative humidity on milk production, composition and technological properties of bulk milk samples from dairy cows of Czech Fleckvieh breed was found:

- with increasing average diurnal temperature in stable statistically highly significantly increases active acidity and rennet coagulation time, amount of milk fat was increasing very highly significantly.
- with increasing average diurnal temperature in stable statistically significantly decreases milk yield and specific density of milk, titratable acidity was decreasing statisticaly highly significantly.

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