HOT STRESS OF HOLSTEIN DAIRY COWS AS SUBSTANTIAL FACTOR OF MILK COMPOSITION*

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The aim of paper was to estimate the effect of hot stress on milk composition and its health indicators. Bulk and individual milk samples (MSs) from Holstein high-yielding cows (11 000 kg and 9022 ± 1015 kg per lactation) in summer season (from May to September) were used. The differences between hot (HDs, 17.63 ± 4.10 °C of day temperature average (DTA)) and normal (NDs, 13.07 ± 4.09 °C) days were tested. The seasonal effect on milk composition was eliminated. In total there were analysed 120 bulk (HDs = 69, NDs = 51) and 1380 individual MSs (HDs = 751, NDs = 629). Protein was reduced by HDs in June (3.00 < 3.07%; $P < 0.001$), July (3.00 < 3.07%; $P < 0.05$) and in total (3.07 < 3.11%; $P < 0.05$), similarly solids non fat in June (8.48 < 8.56%; $P < 0.001$), August (8.48 < 8.55%; $P < 0.05$) and in total (8.54 < 8.59%; $P < 0.01$). Fat (F), lactose, total solids and urea were influenced insignificantly. Bulk milk somatic cell count (SCC) was also not influenced. Low influence of hot stress on F and SCC was not expected. In individual MSs (suspect on mastitis) the highest difference in SCC between HDs and NDs was in May (770 > 542 ths.ml^{-1}; $P > 0.05$). SCCs were higher ($P > 0.05$) in HDs in May, June and August. In total the SCC was higher ($P > 0.05$) in HDs (788 > 714 ths.ml^{-1}). HDs can elevate the SCC in milk of cows which are suffering from secretion disorders by 10.4%. In spite of the use of ventilation system the hot stress can influence milk quality in negative way in high-yielding dairy cows.

dairy cow; Holstein; raw milk; hot stress; proteins; fat; somatic cell count; urea

INTRODUCTION

Ecological aspects of possible animal hot stress

Some of papers (Bartholy, Pongrácz, 2007; Goubanova, Li, 2007) deal with various aspects of rise confirmation, development and simulation of possible impacts of global warming and glasshouse effect on the climate and life on the globe. Bartholy and Pongrácz (2007) confirmed the strongest increasing tendency in annual numbers of hot days and warm nights in the Carpathian basin during the second half of the 20th century. Also the occurrence of extreme water precipitation was increased while the total precipitation was decreased. In general it is possible to judge on more marked changes and so, it is necessary to calculate with these new facts according to results of these papers (Thomassen, Boer, 2005; Bartholy, Pongrácz, 2007; Delarue et al., 2007; Goubanova, Li, 2007; Levy et al., 2007). For instance the occurrence frequency of tropical days can increase under the European conditions. This fact can have an impact on range, way and results of keeping of farm animals. The net effect of European grassland on global warming potential (23 Tg C/year) could correspond to 2.5% increase on the EU-15 fossil fuel CO_2 (907 Tg C/year) emission (Levy et al., 2007).

In spite of the fact that global climate changes are exactly detectable these are simultaneously underestimated by technocrats not seldom. These changes cause evincible enhancement of tropical day occurrence frequency also in central Europe. In consequence of this fact, it is possible to state more frequent occurrence of hot stress in the human population as well as in the population of farm animals. Some opinions argue with periodicity of alternation of small ice and warming periods, which are fastened on the current events with such rationale that it could be also the natural oscillation of Earth's climate now.

Stress and its stressors

Dairy cow thermoneutral zone is defined as environmental air temperature range from 3 to 12 °C and thermical stress starts already from ≥ 25 °C. That is the reason why cattle is phylogenetically determined as arctic animal. Stress is described as reaction and its physiological and no physiological impacts on organism. Currently, it is possible to insert rightly the hot stress into category of production disorders beside mastitis, ketosis, acidosis and so on, especially in the dairying. It deteriorates the animal welfare, their health condition, reproduction performance and the livestock product quality as well (Dolejš et al., 1996a, b, 2000a, b; Illek et al., 2007; Vokřálová et al., 2007).

Possible effects of cow stress on milk

Stress has many factors, stressors, it means no physiological agents. There are a lot of situations where stress

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can arise in the practice of cow rearing. The milking can cause the cow stress both by noise and by vibrations, which can be carried by machine milking (pipeline equipment and also in milking parlours). Here, the different technical systems for blocking of such effects are developed (Nosal, Bilgery, 2004). Of course, stress can be caused also due to poor function of machine milking. This is more frequent in older pipeline machine milking equipment. Under these circumstances Hanuš and Ticháček (1997) mentioned the significant increase of somatic cell count (SCC) by 16.7% ($P < 0.05$) with increase of frequency of simultaneous defects on pipeline milking equipment ($r = 0.26$; $P < 0.001$), which can also cause a cow stress.

Already Famigli-Bergamini (1987) stated the stress as one of important factors of milk quality changes, where it is possible to expect an increase of SCC simultaneously with decrease of milk yield and milk fat content (F) according to schematic prediction. Hanuš et al. (1994) described the possible interpretation of SCC level and lactose content (L) combination in bulk milk in consideration of possible incidence of stress in dairy herd. This is characterized by time increase of the first and by stability of the second mentioned indicator as compared to declared reference values. Also the inundation stress of dairy cow herd was described (Hanuš et al., 1998). The SCCs were increased during short-period part flooding of tie-stable by 70% (from 300 to 1000 ths.ml^{-1}). Hygienic milk indicators, which depend not so much on animal stress as on staff stress and possible errors as total mesophilic bacteria count (TMBC) and coli bacteria, varied otherwise but did not reach the character of SCC increase. In particular the TMBCs corresponded still to limit of extra milk quality in principle (≤ 50 ths.CFU.ml^{-1}). The transport stress due to transport of animals and their transfer into different rearing group and its effect on organism and its yield mentioned Nový and Froňková (1997) and Šoch et al. (2003).

One of the important stressors can be also environmental air temperature. Brouček et al. (1990) observed the significantly higher concentration of free fatty acids in dairy cow blood during high environmental temperatures (day 34 ºC, night 23 ºC). The concentrations of cortisol and insulin were increased insignificantly. Brouček et al. (1995) investigated the significantly higher F (4.22 versus 4.18%), the identical protein content (P; 3.19%) and lower L monohydrate (4.59 versus 4.67%) in milk in high-yielding Holstein dairy cows, which were housed in the low environmental air temperature (–7.3 ºC; the hypothermal stress) in comparison to the normal temperature (7.2 ºC). By contrast to these facts the production was higher for all three components. However, higher was also SCC (793 versus 360 ths.ml^{-1}). The impact of high air temperature on milk yield of cows stated Brouček et al. (2006). The evaporation cooling (EC) by mist increased milk and protein yield markedly by 22.0% and 18.8% ($P < 0.05$). Dolejš et al. (1996a) found a significant decrease of TMBC in milk at application of EC during hot stress of dairy cows. However, they did not find the same trend for SCCs, which were the lowest at 16, highest at 21 and at 31 °C SCCs decreased without EC use on 191 and with EC use on 178 ths.ml^{-1} (it means by 6.8%). Dolejš et al. (1996b) mentioned simultaneously the F, P and solid non fat (SNF) decrease in milk with increase of air temperature. After it the method of EC at temperature 31 °C showed the F decrease (by 3.1%), but also increase of P (by 6.1%) in milk. On the basis of experimental results with alternating of cooling period they estimated and introduced the possible schedule of EC control including liquid addition (Yamamoto et al., 1989; Dolejš et al., 2000a) as positive measure into rearing environment of dairy cows. The EC method decreased the body surface temperature of dairy cows by 3 K during 3.5 minutes (Dolejš et al., 2000b).

Knížková et al. (1996) examined the EC impact on temperatures of heifer body surface and hot stress elimination. The thermovision showed the decrease of body surface temperature by 1.2 °C during shower application for 60 seconds at environment temperature 29 °C. It was enough to cooling of animals for 45 till 60 minutes. Koubková et al. (2002) mentioned the important increase of urea simultaneously with opposite glucose course in physiological and biochemical indicators of dairy cow blood. The high temperatures before it increased the rectal temperature of animals by 2.0 °C and breath and beat frequency. The EC modified better the physiological than biochemical indicators. Knížková and Kunc (2002) noted the significant decrease in haemoglobin, haematocrit and erythrocyte count, while the leukocyte count was not significantly influenced at use of water evaporation cooling of dairy cows during heat stress (32 ºC) compared with the hot period without cooling. The essential question so is expected response of high-yielding dairy cows on mentioned stress factors in particular in milk quality.

Aim of paper

The impacts of hot stress on animal health and their reproduction performance and milk yield were described many times. Already lower number of works exists about its impact on milk quality and milk health indicators. The aim of this work was to estimate the effect of higher frequency of hot stress occurrence on milk composition and its health indicators in order to reach the possibility of prevention method improvement and the decrease its impacts on milk quality.

MATERIAL AND METHODS

Environmental conditions of experimental investigation and animals

The high-yielding dairy cow herd (Holstein breed) is kept in altitude 250 m with total water precipitation 665 and 652 mm (2005 and 2006) and average year air temperature 7.8 and 8.1 °C. During the whole year the animals were fed by total mixed ration, which was offered by feed-

Table 1. Impact of normal (NDs) and hot (HDs) days on bulk milk composition (F = fat, P = crude protein, L = lactose, all in %) in the high yield dairy cow herd in summer months

Month	Par.	NDs			HDs			*t*-test + sign.		
		F	P	L	F	P	L	F	P	L
May	*n*	9	9	9	12	12	12			
	x	3.67	3.05	4.96	3.56	3.03	4.97	1.26 ns	0.60 ns	0.22 ns
	sd	0.224	0.046	0.037	0.177	0.079	0.035			
	vx	6.1	1.5	0.8	5.0	2.6	0.7			
June	*n*	9	9	9	15	15	15			
	x	3.41	3.07	4.94	3.51	3.00	4.93	1.36 ns	4.16 ***	1.08 ns
	sd	0.161	0.044	0.028	0.191	0.036	0.025			
	vx	4.7	1.4	0.6	5.4	1.2	0.5			
July	*n*	9	9	9	12	12	12			
	x	3.25	3.07	4.95	3.30	3.00	4.96	0.50 ns	2.30 *	0.48 ns
	sd	0.136	0.041	0.027	0.271	0.073	0.043			
	vx	4.2	1.3	0.5	8.2	2.4	0.9			
August	*n*	11	11	11	15	15	15			
	x	3.33	3.08	4.92	3.41	3.04	4.90	1.07 ns	1.74 ns	1.59 ns
	sd	0.159	0.061	0.036	0.205	0.059	0.029			
	vx	4.8	2.0	0.7	6.0	1.9	0.6			
September	*n*	12	12	12	15	15	15			
	x	3.61	3.23	4.91	3.53	3.24	4.91	0.83 ns	0.27 ns	0.12 ns
	sd	0.268	0.063	0.024	0.194	0.076	0.029			
	vx	7.4	1.9	0.5	5.5	2.3	0.6			
Total	*n*	50	50	50	69	69	69			
	x	3.46	3.11	4.93	3.47	3.07	4.93	0.19 ns	2.15 *	0.60 ns
	sx	0.251	0.087	0.036	0.222	0.113	0.041			
	vx	7.3	2.8	0.7	6.4	3.7	0.8			

Abbreviations for all tables and figures: Par. = parameter, *n* = number of cases, *x* = arithmetical mean, *ag* = geometrical average, *sd* = standard deviation, *vx* = variation coefficient in %, min. = minimum, max. = maximum, sign. = statistical significance, ns = insignificant, $P > 0.05$, *, ** and *** = significant, $P < 0.05$, $P < 0.01$ and $P < 0.001$

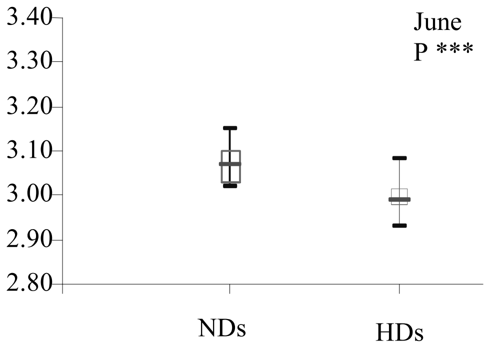

Fig. 1. Impact of NDs and HDs on crude protein (P in %) in bulk cow milk in June

For all box graphs: median (the central short horizontal line); top edge of 1st and 3rd quartile (the tetragon); variation range, maximum – minimum (the vertical line))

ing wagon. TMR varied minimally during the whole period and consists of: 20 kg of alfalfa silage; 20 kg of maize silage; 2.5 kg of meadow hay; 12 kg of brewery draff; 3.0 kg of mashed grain; 0.7 kg of soya bean meal; 1.0 kg of rape seed meal; 4.0 kg of CCM (maize corn silage in bag); 0.25 kg of TOP mixture of concentrates for top of lactation; mineral mixture; glycerol at the beginning and top of lactation. The animals (510 head) showed milk yield 11 000 kg per lactation and were milked in the autotandem milking parlour (2 × 6) three times per day. It is valid for set of bulk milk samples (I; *n* = 119). The milk yield of selected cows with milk secretion problems (II; *n* = 1380) was 9022 ± 1015 kg per lactation on average. The service period of herd was 152 days and corresponded to calving period 418 days. Normally 5% of milk was excluded because of occurrence of milk secretion disorders and their antibiotic therapy. The animals were housed in the reconstructed airy free stable with cross lie down boxes and straw strewing. Cooling of cows by high-speed ventilators was used in the stable during hot summer days (over 20 °C).

The definition of hot days

The outdoor air temperature was measured every twenty minutes during day and the day temperature average (DTA) was calculated in the period from the beginning of May to the end of September 2007. The milk samples were obtained in the hot days (HDs) as experimental and in

Table 2. Impact of normal (NDs) and hot (HDs) days on bulk milk composition (SNF = solids non fat, TS = total solids in %, U = urea in mg.100 ml^{-1}) in the high yield dairy cow herd in summer months

Month	Par.	NDs			HDs			*t*-test + sign.		
		SNF	TS	U	SNF	TS	U	SNF	TS	U
May	*n*	9	9	9	12	12	12			
	x	8.57	12.24	33.79	8.55	12.11	30.12	0.50 ns	1.13 ns	2.65 *
	sd	0.071	0.280	2.639	0.064	0.229	3.222			
	vx	0.8	2.3	7.8	0.7	1.9	10.7			
June	*n*	9	9	9	15	15	15			
	x	8.56	11.97	31.61	8.48	11.99	30.18	4.86 ***	0.23 ns	1.12 ns
	sd	0.050	0.180	3.525	0.034	0.209	2.413			
	vx	0.6	1.5	11.2	0.4	1.7	8.0			
July	*n*	9	9	9	12	12	12			
	x	8.56	11.81	37.17	8.51	11.81	39.25	1.80 ns	0.07 ns	0.84 ns
	sd	0.041	0.137	3.515	0.084	0.213	6.339			
	vx	0.5	1.2	9.5	1.0	1.8	16.2			
August	*n*	11	11	11	15	15	15			
	x	8.55	11.88	33.23	8.48	11.89	33.07	2.18 *	0.19 ns	0.13 ns
	sd	0.080	0.198	3.105	0.070	0.208	2.979			
	vx	0.9	1.7	9.3	0.8	1.8	9.0			
September	*n*	12	12	12	15	15	12			
	x	8.69	12.30	34.00	8.70	12.23	33.21	0.35 ns	0.63 ns	0.47 ns
	sd	0.060	0.303	4.453	0.068	0.239	3.257			
	vx	0.7	2.5	13.1	0.8	2.0	9.8			
Total	*n*	50	50	50	69	69	66			
	x	8.59	12.05	33.93	8.54	12.01	33.03	2.60 **	0.74 ns	1.07 ns
	sd	0.082	0.299	3.826	0.106	0.261	4.908			
	vx	1.0	2.5	11.3	1.2	2.2	14.9			

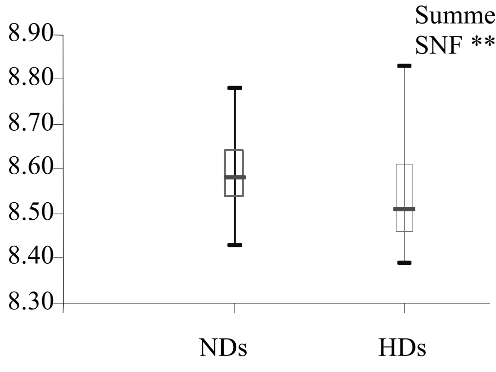

Fig. 2. Impact of NDs and HDs on solids non fat (SNF in %) in bulk cow milk in total

normal days (NDs) as reference. As HD was defined the day with above-average DTA within month and as ND with below the average DTA within relevant month. In this way following discrimination temperature limits (in the brackets) existed within individual months in accordance with average values and their variability for DTA: May 10.89 ± 4.89, (11.0); June 16.46 ± 2.51 (16.0); July 19.08 ± 4.17 (18.0); August 19.53 ± 2.58 (19.0); September 12.23 ± 1.01 (12.0) °C. Total average of DTA during summer season and its variability was 15.68 ± 4.64 °C.

Milk samples and their analyses

Milk was sampled regularly two times per week as bulk (I) samples (each day sample was measured in three variants, which corresponded to storage tanks, morning, midday and evening) and as individual samples (II) from dairy cows which were suspected of milk secretion disorder occurrence in current moment in the herd. This sampling was carried out according to visible signs (clinical) on the mammary gland or its secret (occurrence of flakes) and or according to positive response of Mastitis test-NK (2+ and more, subclinical symptoms). The number of individual milk samples (MSs) varied from 209 (May) to 394 (August) in the monat sets (in total *n* = 1380, HDs = 751, NDs = 629). The following indicators were analysed in bulk (*n* = from 21 to 27 per month, in total *n* = 120, HDs = 69, NDs = 51) MSs: contents of fat (F), crude protein (P), lactose monohydrate (L), solids non fat (SNF) and total solids (TS). All indicators were expressed in % (instrument Milko-Scan 133 B, Foss Electric, Denmark); somatic cell count (SCC, ths.ml^{-1}; equipment Fossomatic 90, Foss Electric, Denmark); urea concentration (U, mg.100 ml^{-1}; photometrical method at 420 nm and dyeing with p-dimethylaminobenzaldehyde on Spekol 11, Carl Zeiss Jena, Germany). Only SCC was determined in indi-

Table 3. Impact of normal (NDs) and hot (HDs) days on bulk milk comatic cell count (SCC in ths.ml^{-1} and log SCC) in the high yield dairy cow herd in summer months

Month	Par.	NDs		HDs		*t*-test + sign.	
		SCC	log SCC	SCC	log SCC	SCC	log SCC
May	*n*	9	9	12	12		
	x	342	2.5318	341	2.5254	0.03 ns	0.19 ns
	ag		340		335		
	sx	37.079	0.048	67.614	0.086		
	vx	10.8		19.8			
June	*n*	9	9	15	15		
	x	408	2.6076	379	2.5763	1.60 ns	1.57 ns
	ag		405		377		
	sx	48.575	0.051	36.257	0.041		
	vx	11.9		9.6			
July	*n*	9	9	12	12		
	x	403	2.6034	385	2.5793	0.75 ns	0.75 ns
	ag		401		380		
	sx	36.156	0.040	58.275	0.084		
	vx	9.0		15.1			
August	*n*	12	12	15	15		
	x	382	2.5779	417	2.6162	1.51 ns	1.44 ns
	ag		378		413		
	sx	55.193	0.067	59.447	0.065		
	vx	14.4		14.2			
September	*n*	12	12	15	15		
	x	331	2.5104	340	2.5207	0.28 ns	0.26 ns
	ag		324		332		
	sx	74.947	0.097	75.982	0.102		
	vx	22.6		22.3			
Total	*n*	51	51	69	69		
	x	371	2.5636	373	2.5646	0.17 ns	0.06 ns
	ag		366		367		
	sx	60.762	0.075	66.028	0.084		
	vx	16.4		17.7			

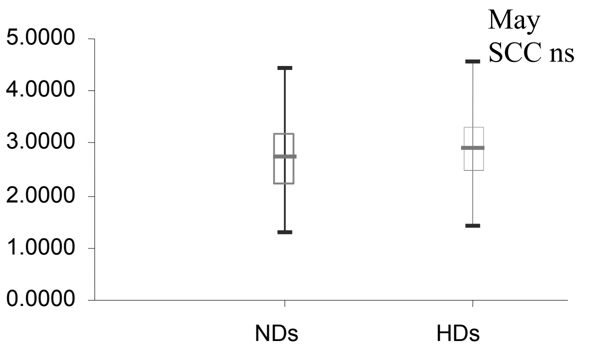

Fig. 3. Impact of NDs and HDs on SCC (expressed as log) in cow milk with suspect of secretion disorders in May

vidual MSs. All analyses were performed according to standard operation manuals of accredited (ČSN EN ISO 17025) National reference laboratory for raw milk.

Statistical evaluation principles

The results of milk indicators were evaluated by basic statistical methods and average differences between ND (13.07 ± 4.09) and HD (17.63 ± 4.10 °C of DTA) were tested by t-test. Temperature difference between NDs and HDs was about 34.9%. SCC values were tested on log transformed scale for approach to data normal frequency distribution and mean values were expressed as geometrical means (Ali, Shook, 1980; Shook, 1982; Reneau, 1986; Janů et al., 2007a). The average values of milk indicators in NDs were taken as reference values for comparison to HDs with thus fact that approximately similar rations of HD MSs to ND MSs in investigated months were used as model for elimination of possible interference of seasonal effect (from 0.99 to 1.58, in total 1.19 in individual MSs and in total 1.35 in bulk MSs) on milk composition. The milk indicator values were assigned always to the day temperature, which was previous to the concrete sampling day.

Table 4. Impact of normal (NDs) and hot (HDs) days on somatic cell count (SCC in ths.ml^{-1}) in the individual milk samples from mastitis suspect cows along summer months

Month	Parameter	NDs	HDs	*t*-test criterion	Sign.
May	*n*	105	104	1.69	ns
	x	1 685	2 184		
	ag	542	770		
	sd	3 775	4 413		
	min.	20	25		
	max.	25 990	34 096		
June	*n*	91	144	1.10	ns
	x	1 194	1 518		
	ag	580	704		
	sd	1 770	2 073		
	min.	22	17		
	max.	12 402	12 324		
July	*n*	96	145	0.29	ns
	x	1 598	1 827		
	ag	774	735		
	sd	2 151	3 157		
	min.	35	27		
	max.	12 466	23 171		
August	*n*	191	203	0.80	ns
	x	2 207	2 366		
	ag	870	975		
	sd	3 605	3 996		
	min.	32	17		
	max.	30 724	34 529		
September	*n*	146	155	0.08	ns
	x	1 800	1 653		
	ag	727	718		
	sd	2 738	3 028		
	min.	28	24		
	max.	19 388	26 898		
Total	*n*	629	751	1.29	ns
	x	1 786	1 927		
	ag	714	788		
	sx	3 047	3 421		
	min.	20	17		
	max.	30 724	34 529		

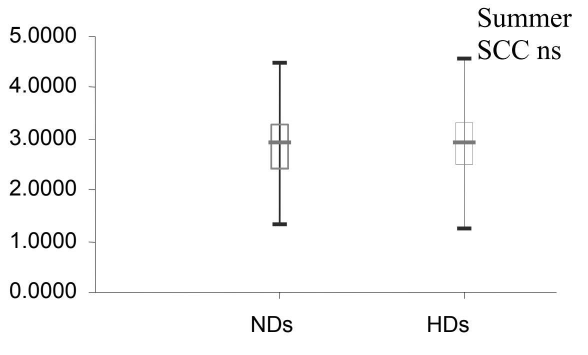

Fig. 4. Impact of NDs and HDs on SCC (expressed as log) in cow milk with suspect of secretion disorders in total

RESULTS AND DISCUSSION

I) An influence of HDs on milk composition was observed about crude protein content (P) and solids non fat (SNF). These impacts were quite consistent in summer months and in whole investigation period. P was reduced by HDs in all months excluding September (Table 1) but in June (3.00 < 3.07%; $P < 0.001$; Fig. 1), in July (3.00 < 3.07%; $P < 0.05$) and during whole summer period (3.07 < 3.11%; $P < 0.05$) it was significant. Similarly SNF content was reduced by hot temperature in June (8.48 < 8.56%; $P < 0.001$; Table 2), in August (8.48 < 8.55%; $P < 0.05$) and also in summer (8.54 < 8.59%; $P < 0.01$; Table 2;

Fig. 2). Also Dolejš et al. (1996b) mentioned the decrease of P and SNF i milk with increase of air temperature. The fat, L, TS and U contents were not influenced significantly by air temperature increase (Tables 1 and 2). TS content was reduced a little by HDs. The urea contents were practically the same during normal and hot days (Table 2). That means that rumen amonium utilization was not influenced by environmental temperature. It is interesting that the SCC was also influenced insignificantly (Table 3). Dolejš et al. (1996a) likewise did not find a clearer temperature trend in SCC in their study. The low influence of hot stress on milk fat content was quite surprising similarly to influence of HDs on SCC in bulk milk. 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., 2007b) which is comparable to influence of environmental temperature variation on F. Dolejš et al. (1996b) found also the milk F content depression with air temperature increase. In general, as the stated HDs-NDs differences, especially for F content and SCC, were less than expected according to some sources it is posssible to suppose that used ventilation system probably moderated a possible hot stress effect in the stable and this investigation.

II) In selected individual MSs with suspect on clinical and mostly subclinical mastitis or milk secretion disorder occurrence in dairy cows the highest insignificant difference in SCC between HDs and NDs was observed in May (770 > 542 ths.ml^{-1}; $P > 0.05$; Table 4; Fig. 3). Also the number of selected cows from herd was regularly higher in HDs as compared to NDs (751 > 629). SCCs were markedly but insignificantly ($P > 0.05$) higher in HDs in May, June and August as compared to NDs. These were only a little and naturally insignificantly lower in HDs in comparison to NDs in July and September. During whole experimental period in individual MSs the SCC was also insignificant ($P > 0.05$) higher in HDs as compared to NDs (788 > 714 ths.ml^{-1}) if expressed as geometrical mean by log transformation (Table 4; Fig. 4). In arithmetical means the result of the same comparison was similar (1927 > 1786 ths.ml^{-1}; Table 4). In mentioned case of research the results showed on this fact that HDs can a little increase SCC as mastitis indicator in milk of dairy cows which are in suspicion of secretion disorder in most of summer months. The SCC elevation could be estimated to 10.4%. As the above mentioned results (part I, bulk milk without reaction of SCC in dependence on environment temperature) about SCC are compared to result evaluation in this investiagation (a consistent but not too high elevation of SCC along hot days) this fact is visible that mostly only cows with subclinical mastitis react on hot stress by SCC elevation The other healthy dairy cows are less susceptible to temperature variation.

CONCLUSION

In spite of the use of the automatic ventilation system for animals cooling in the stable the results showed that hot stress can influence milk quality in negative way in high-yielding dairy cows. It is ncessary to take more care of cooling of cows. The impact of higher frequency and temperature of the hot days on milk under our conditions adds that not only in conventional agriculture but also under supposition of application of organic agriculture rules (Rosati, Aumaitre, 2004) the general ecological consequences can load the livestock production, dairy cow keeping and quality of produced milk.

REFERENCES

ALI, A. K. A. – SHOOK, G. E.: An optimum transformation for somatic cells concentration in milk. J. Dairy Sci., *63*, 1980: 487–490.

BARTHOLY, J. – PONGRÁCZ, R.: Regional analysis of extreme temperature and precipitation indices for Carpathian Basin from 1946 to 2001. Global Planet. Change, *57*, 2007: 83–95.

BROUČEK, J. – KOVALČIKOVÁ, M. – KOVALČIK, K. – LETKOVIČOVÁ, M.: Variations of biochemicals indicators in dairy cows to alternate influence of high temperatures. Živoč. Výr., *35*, 1990: 17–26. (In Slovak)

BROUČEK, J. – ARAVE, C. W. – NAKANISHI, Y. – MIHINA, Š. – HETÉNYI, L.: Effect of hypothermal stress on milk composition and health of dairy cows. Živoč. Výr., *40*, 1995: 193–201. (In Czech)

BROUČEK, J. – MIHINA, Š. – RYBA, Š. – TONGEĽ, P. – KIŠAC, P. – UHRINČAŤ, M. – HANUS, A.: Effects of high air temperature on milk efficiency in dairy cows. Czech J. Anim. Sci., *51*, 2006: 93–101.

DELARUE, E. – LAMBERTS, H. – D´HAESELEER, W.: Simulating greenhouse gas (GHG) allowance cost and GHG emission reduction in Western Europe. Energy, *32*, 2007: 1299–1309.

DOLEJŠ, J. – TOUFAR, O. – KNÍŽEK, J.: The stable temperature influences milk microbial quality. Náš Chov, *56* (8), 1996a: 13. (In Czech)

DOLEJŠ, J. – TOUFAR, O. – KNÍŽEK, J.: The temperature of rearing environment affects on milk chemical composition. Náš Chov, *56* (7), 1996b: 20. (In Czech)

DOLEJŠ, J. – TOUFAR, O. – KNÍŽEK, J.: The influence of a non-homogeneous temperature field on dairy cows. Czech J. Anim. Sci., *45*, 2000a: 33–36. (In Czech)

DOLEJŠ, J. – TOUFAR, O. – KNÍŽEK, J.: Evaporative cooling of cows in a nonhomogeneous temperature field. Czech J. Anim. Sci., *45*, 2000b: 75–80. (In Czech)

FAMIGLI–BERGAMINI, P: Rapporti tra patologia (non mammaria) ed aspetti quali-quantitativi del latte nella bovina. Societa Italiana di Buiatria, Bologna, *19* (8–10), 1987: 89–99.

GOUBANOVA, K. – LI, L.: Extremes in temperature and precipitation around the Mediterranean basin in an ensemble of future climate scenario simulations. Global Planet. Change, *57*, 2007: 27–42.

HANUŠ, O. – TICHÁČEK, A.: Analysis of milking technique effect on somatic cell counts. Stočarstvo, *51*, 1997: 121–128.

HANUŠ, O. – BENDA, P. – TICHÁČEK, A.: Inundation stress in dairy cows and its effects on milk quality. Veterinářství, 1998 (2): 50–51. (In Czech)

HANUŠ, O. – BEBER, K. – NECHVÁTAL, R. – KOUŘIL, P. – GENČUROVÁ, V. – KOPECKÝ, J. – GABRIEL, B.: The lactose content and secretion disorders of cow's mammary gland in the milk recording. Výzk. Chovu Skotu, 1994 (3): 12–17. (In Czech)

HANUŠ, O. – FRELICH, J. – JANŮ, L. – MACEK, A. – ZAJÍČKOVÁ, I. – GENČUROVÁ, V. – JEDELSKÁ, R.: Impact of different milk yields of cows on milk quality in Bohemian spotted cattle. Acta Vet. Brno, *76* (4), 2007: 563–571.

ILLEK, J. – KUDRNA, V. – MATĚJÍČEK, M. – NOVÁK, P. – SLAVÍK, P.: Heat stress in dairy cows – health, production and reproduction. Náš Chov, *67* (6), 2007: 63–65. (In Czech)

JANŮ, L. – HANUŠ, O. – BAUMGARTNER, CH. – VYLETĚLOVÁ, M. – JEDELSKÁ, R.: The analysis of state, dynamics and properties of raw cow milk quality indicators in the Czech Republic. Acta Fytotechn. Zootechn., *10* (3), 2007a: 74–85.

JANŮ, L. – HANUŠ, O. – FRELICH, J. – MACEK, A. – ZAJÍČKOVÁ, I. – GENČUROVÁ, V. – JEDELSKÁ, R.: Influences of different milk yields of Holstein cows on milk quality indicators in the Czech Republic. Acta Vet. Brno, *76* (4), 2007b: 553–561.

KNÍŽKOVÁ, I. – KUNC, P.: The influence of water evaporative cooling on haematological parameters in dairy cows during heat stress. Folia Veter., *46* (2), 2002: S18–S19.

KNÍŽKOVÁ, I. – KUNC, P. – NOVÝ, Z. – KNÍŽEK, J.: Evaluation of evaporative cooling on the changes of cattle surface body temperatures with use of thermovision. Živočišná Výroba, *41*, 1996: 433–439. (In Czech)

KOUBKOVÁ, M. – KNÍŽKOVÁ, I. – KUNC, P. – HÄRTLOVÁ, H. – FLUSSER, J. – DOLEŽAL, O.: Influence of high environmental temperatures and evaporative cooling on some physiological, hematological and biochemical parameters in high-yelding dairy cows. Czech J. Anim. Sci., *47*, 2002: 309–318.

LEVY, P. E. – MOBBS, D. C. – JONES, S. K. – MILNE, R. – CAMPBELL, C. – SUTTON, M. A.: Simulation of fluxes of greenhouse gases from European grasslands using the DNDC model. Agr. Ecosyst. Environ., *121*, 2007: 186–192.

NOSAL, D. – BILGERY, E.: Aiborne noise, structure-borne sound (vibration) and vacuum stability of milking systems. Czech J. Anim. Sci., *49*, 2004: 226–230.

NOVÝ, Z. – FROŇKOVÁ, S.: Transport stress of farm animals and possibili its elimination. Farmář, 1997 (10): 52. (In Czech)

RENEAU, J. K.: Effective use of dairy herd improvement somatic cell counts in mastitis control. J. Dairy Sci., *69*, 1986: 1708–1720.

ROSATI, A. – AUMAITRE, A.: Organic dairy farming in Europe. Livest. Prod. Sci., *90*, 2004: 41–51.

SHOOK, G. E.: Approaches to summarizing somatic cell count which improve interpretability. Nat. Mast. Council, Louisville, Kentucky, 1982: 1–17.

ŠOCH, M. – MILÁČEK, M. – NOVÁK, P. – BROUČEK, J.: The impact of transfer of cows into new group on their milk yield. Náš Chov, *63* (12), 2003: 14–16. (In Czech)

THOMASSEN, M. A. – BOER DE, I. J. M.: Evaluation of indicators to assess the environmental impact of dairy production system. Agr. Ecosyst. Environ., *111*, 2005: 185–199.

VOKŘÁLOVÁ, J. – NOVÁK, P. – ILLEK, J. – BRIX, M. – ODEHNALOVÁ, S. – IHNÁT, O.: The impact of climate on milk production. Náš Chov, *67* (6), 2007: 66–68. (In Czech)

YAMAMOTO, A. – YAMAMOTO, S. – YAMAGUSHI, N. – SHISHIDO, H.: Effects of environmental temperature and air movement on thermolegulatory responses of lactating cows – An assessment of air movement in terms of effective temperature. Jap. J. Zootechn., *60*, 1989: 728.

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Tepelný stres holštýnských dojnic jako významný faktor složení mléka.

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Cílem práce bylo odhadnout vliv stresu z horka na složení mléka a jeho zdravotní ukazatele. Byly použity bazénové a individuální vzorky mléka (MSs) od holštýnských vysokoužitkových krav (11 000 kg a 9 022 ± 1 015 kg za laktaci) v letní sezoně (od května do září). Testovány byly rozdíly mezi horkými (HDs, 17,63 ± 4,10 °C průměrné denní teploty (DTA)) a normálními (NDs, 13,07 ± 4,09 °C) dny. Byl omezen sezonní vliv na složení mléka. Celkově bylo analyzováno 120 bazénových (HDs = 69, NDs = 51) a 1 380 individuálních MSs (HDs = 751, NDs = 629). V důsledku HDs byly bílkoviny sníženy v červnu (3,00 < 3,07 %; $P < 0{,}001$), červenci (3,00 < 3,07 %; $P < 0{,}05$) a celkem (3,07 < 3,11 %; $P < 0{,}05$), podobně sušina tukuprostá v červnu (8,48 < 8,56 %; $P < 0{,}001$), srpnu (8,48 < 8,55 %; $P < 0{,}05$) a celkem (8,54 < 8,59 %; $P < 0{,}01$). Tuk (F), laktóza, celková sušina a močovina nebyly významně ovlivněny. Bazénový počet somatických buněk (SCC) rovněž nebyl ovlivněn. Nízký vliv tepelného stresu na F a SCC nebyl očekáván. V květnu byl největší rozdíl v SCC mezi HDs a NDs u individuálních MSs (dojnice podezřelé z mastitidy; 770 > 542 tis.ml^{-1}; $P > 0{,}05$). SCC byly vyšší ($P > 0{,}05$) v HDs v květnu, červnu a srpnu. Celkově byl SCC vyšší ($P > 0{,}05$) v HDs (788 > 714 tis.ml^{-1}). HDs mohou zvýšit SCC v mléce krav, které trpí poruchami sekrece, o 10,4 %. Vzdor použití ventilačního systému může tepelný stres ovlivnit negativně kvalitu mléka vysokožitkových dojnic.

dojnice; holštýnské plemeno; syrové mléko; tepelný stres; bílkoviny; tuk; počet somatických buněk; močovina

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