A COMPARISON OF LACTATION PHYSIOLOGY EFFECTS AT HIGH AND LOWER YIELD ON COMPONENTS, PROPERTIES AND HEALTH STATE INDICATORS OF MILK IN CZECH FLECKVIEH*

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The milk yield (MY) is one of the main efficiencies of Czech Fleckvieh (CF) cattle. It is evaluated through milk recording. MY is a significant economic and health factor. Differences within milk indicators (MIs) between two CF dairy cow groups with high (CF1; $n = 213$ individual milk samples (animals)) and lower (CF2; $n = 265$) MY were tested. The files were balanced in factors of lactation. Group 1 had higher genetical value and even better nutrition according to the MY. Average daily milk yield of CF1 was higher by 56% as compared to CF2 ($P \leq 0.001$). Significant differences ($P \leq 0.001$) were determined for: fat (FAT); lactose (LAC); solids non fat (SNF); log somatic cell count (log SCC); crude protein (CP); casein (CAS); true protein (TP); fat/crude protein ratio (F/CP). FAT, LAC and SNF differed markedly ($P \leq 0{,}001$) in this way the CF1 cows had lower milk FAT, LAC and SNF as compared to CF2 (3.71–4.33%, 5.00–4.92% and 8.83–8.97%). The log SCC was significantly lower in CF1 dairy cows (*xg* 50–74 $10^3.ml^{-1}$). It was found higher level of milk lactation in the cow herds without diseases. However, the difference was relatively small. CF1 group had higher genetic potential and higher feedstuff consumption within herd. Further, there were significant differences between CF1 and CF2 in milk nitrogen fraction for CP, CAS and TP (3.30–3.53%, 2.62–2.81% and 3.11–3.33%). The next significant ($P \leq 0.05$) differences were at electrical conductivity (CF1 > CF2), time for enzymatic coagulation (renneting ability; CF1 < CF2), rennet curds firmness (CF1 < CF2), whey volume after renneting (CF1 > CF2), whey protein (CF1 < CF2) and ratio of urea nitrogen in the non protein nitrogen (CF1 > CF2). Insignificant differences existed for the next 9 MIs (as acetone, pH, titration acidity, alcohol stability, casein number). Surprisingly, higher milk urea (U) was not linked with higher MY in CF breed. The differences in MIs between CF1 and CF2 do not represent health troubles. High MY which was reached by genetic improvement and more effective nutrition did not lead to aggravated milk quality, but lead to its lower technological recovery.

dairy cow; Czech Fleckvieh cattle; milk yield; milk components; health milk indicators; physical and technological properties

INTRODUCTION

Cattle breeding is one of the fundamental branches of livestock production. Efficiency of animals is increasing with the perfecting of breeding. Czech Fleckvieh (CF) are dual purpose cattle. Results of exterior breeding work in CF were described by Kučera (2009).

It is indubitable that markedly different cow milk yields have to be subject to genetically based variants of physiological lactation control also within the breed. The ground is a different ability for utilization of nutrients. The high milk yield (MY) can be accompanied by higher susceptibility of individuals to environmental factors and can modify milk composition and properties regarding its processing and use as foodstuff. High MY can also be an easier target of occurrence of the so-called dairy cow production disorders according to practice opinions. It has to be balanced by higher levels of control of animal health state and environmental conditions. It should be realized by regular health state monitoring, animal nutrition control and disorder prevention.

High MY is often preferred because of higher milk money income. However, high MY is also criticised because of suspicions of possible negative impact on animal health, poor reproductive performance and longevity. Such negative impacts of a long period protein over-loading of dairy cow metabolism by nutrition to ensure high MY were found (Hanuš et al., 2001a; Miglior et al., 2006). This and aggravated reproductive performance were connected with high urea concentrations in dairy cow body fluids (Piatkowski et al., 1981; Ropstad, Refsdal, 1987; Butler et al., 1996; Larson et al., 1997; Říha, Hanuš, 1999a, b; Guo et al., 2004; Hojman et al., 2004; Kubešová et al., 2008; Bezdíček et al., 2009).

The average MY has been increased approximately by more than 45% in the Czech Republic during the last fifteen years (Kvapilík, 2002; Kvapilík, Střele-

* The study was supported by projects MSMT, MSM 2678846201 and ME 09081.

ček, 2003; Kvapilík et al., 2002, 2003, 2004; Kučera, Král, 2004; Hanuš, Kvapilík, 2006; Kvapilík et al., 2009). A practical discussion if the milk production is more effective by six and/or nine thousand kg of milk per lactation exists among veterinarians and farmers. Of course, it depends on many external and internal factors. Generally valid answers do not exist. MY is increased by genetical improvement in dairy herd. Increasing the number of times daily milking and improvement of cow nutrition are the next used methods.

The aim of this paper was to study possible effects of higher MY on a wide scale of milk components and properties in Czech Fleckvieh in terms of importance for the processing industry. Additionally, possible impacts of high MY on milk indicators of cow health state were also study objects. We compared the higher number of the MIs between high and low MY than is usually known in previous studies (Suchánek, Hanuš, 1997; Kučera, Král, 2004).

MATERIAL AND METHODS

Animals, herd and their keeping conditions

During three years of experimental investigation, the individual milk samples (MSs) were taken in four herds of Czech Fleckvieh dairy cows. Animals were selected from herd for sampling as follows: with higher MY in herd; according to typical herd profile in terms of stage and number of lactation; only clinical and strong subclinical mastitis free. In this way the animal groups represented the real herd with respect to the mentioned breeder's factors. MSs were collected regularly in summer (August, September) and winter (February, March) feeding season. Animals were fed with addition of the concentrates according to MY and standard demands. The feeding rations consisted of roughage as follows according to herds: alfalfa silage + maize silage for whole year (herd 1); grass silage + GPS (silage) from cereals (or maize silage or sugar beet chips) in winter and similar mixture in the combination with grass pasture in summer (herd 2); clover (clover and grass) silage + maize silage for the whole year (herd 3); grass silage + maize silage for the whole year (herd 4). Nutrition was not equal among herds. All dairy cows were milked twice a day (Ayadi et al., 2003; Remond et al., 2004). Herds were kept in altitude from 230 to 670 m above the sea level.

Milk sample analyses

The analyses were performed in the accredited laboratory of the Research Institute for Cattle Breeding in Rapotín. MSs were analysed as preservation free and or preserved (with bronopol 0.04%) after cooling transport (< 10 °C). The following health milk indicators were noted and analysed (Table 1): DMY = daily milk yield (kg of milk/day); FAT = fat (g/100 ml; %); LAC = lactose (monohydrate; g/100 g; %); SNF = solids non fat (g/100 g; %); SCC = somatic cell count (10^3.ml^{-1}); U = urea (mg.100 g^{-1}); AC = acetone (mg.l^{-1}); pH = H ions; EC = electrical conductivity (mS.cm^{-1}); AL = alcohol stability (in ml); SH = titration acidity (in ml of 0.25 mol.l^{-1} NaOH solution for 100 ml of milk); TEC = time for enzymatic coagulation (in seconds); RCQ = subjective estimation of the rennet curds quality (in classes from 1 = excellent to 4 = poor); RCF = rennet curds firmness (in mm in contrary to real firmness value, the more mm, the poorer curds firmness); WV = whey volume (in ml after 1 hour coagulation); CP = crude protein (Kjeldahl total N × 6.38; g/100 g; %); CAS = casein (Kjeldahl casein N × 6.38; g/100 g; %); TP = true protein (Kjeldahl protein N × 6.38; g/100 g; %); WP = whey protein (difference TP – CAS; g/100 g; %); NPN = non protein nitrogen matter (CP – TP nitrogen × 6.38; g/100 g; %); URN = ratio of urea nitrogen in the non protein nitrogen (%); F/CP = fat/crude protein ratio. The casein numbers on the basis of crude and true protein in % (CN-CP, CN-TP). Other details about milk analyses were published previously (Janů et al., 2007; Hanuš et al., 2007; Sojková et al., 2010).

Table 1. Used abbreviations of milk chemical components, health indicators and physical and technological properties

n	number of incidents	–
DMY	daily milk yield	kg/day
FAT	fat	%
LAC	lactose	%
SNF	solids non fat	%
SCC	somatic cell count	10^3.ml^{-1}
log SCC	logaritmus of somatic cell count	–
U	urea	mg.100g^{-1}
AC	acetone	mg.l^{-1}
log AC	logaritmus acetone	–
pH	acidity	–
EC	electrical conductivity	mS.cm^{-1}
AL	alcohol stability	ml
SH	titration acidity	ml 0.25 mol.l^{-1} NaOH
TEC	time for enzymatic coagulation	second
RCQ	rennet curds quality	class
RCF	rennet curds firmness	mm
WV	whey volume	ml
CP	crude protein	%
CAS	casein	%
TP	true protein	%
WP	whey protein	%
NPN	non protein nitrogen	%
URN	urea nitrogen/non protein nitrogen ratio	%
F/CP	fat/crude protein ratio	%
CN-CP	casein numbers of crude protein	%
CN-TP	casein numbers of fat	%

Statistical evaluation

All animals were grouped approximately in halves in their herds according to their own lactation MY: CF1 (over real group average lactation MY within herd, high MY); CF2 (below real group average lactation MY, lower MY in terms of country breed MY results). CF1 and CF2 groups from herds were put together: CF1 (animals with high MY – x = 32.1 kg/day, from all herds; n = 213 MSs /animals/); CF2 (animals with lower MY – x = 20.6 kg/day, from all herds; n = 265). The effects of sampling season, herd conditions, lactation stage and lactation number were balanced in this way (Table 2). High MY was reached by a higher level of individual genetic basis and more effective nutrition, it means a higher consumption of roughage and concentrates by animals.

Milk indicator values with no normal data frequency distribution (SCC and AC) were log transformed (Ali, Shook, 1980; Raubertas, Shook, 1982; Sawa, Piwczynski, 2002; Foltys, Kirchnerová, 2001; Shook, 1982; Reneau, 1986; Wiggans, Shook, 1987; Reneau et al., 1988; Hanuš et al., 1995, 1999, 2001b). The basic statistical characteristics were calculated (Excel programme): arithmetic mean (x); geometric mean (xg); standard deviation (sd); median. Average group differences in milk indicators were investigated by t-test. Group frequency distributions of milk indicators with significant differences were demonstrated by box graphs.

RESULTS AND DISCUSSION

The average DMY in CF1 was higher by 56% than in CF2 and this high difference was significant ($P < 0.001$; Table 2 and Fig. 1, DMY). The studied high MY factor

Table 2. Differences in milk chemical components, health indicators and physical and technological properties between CF cows with high (CF1) and lower (CF2) MY.

	CF1		CF2		t	Sign.
	$x \pm sd$	xg	$x \pm sd$	xg		
n	213		265			
NL	2.61 ± 1.38		2.50 ± 1.44		0.84	ns
SL	142.3 ± 76.6		147.3 ± 72.2		0.73	ns
DMY	32.1 ± 6.7		20.6 ± 4.6		22.06	***
FAT	3.71 ± 0.89		4.33 ± 0.84		7.79	***
LAC	5.00 ± 0.21		4.92 ± 0.20		4.25	***
SNF	8.83 ± 0.35		8.97 ± 0.34		4.44	***
SCC	143 ± 424		218 ± 589		1.56	ns
log SCC	1.7020 ± 0.5371	50	1.8715 ± 0.5387	74	3.42	***
U	30.60 ± 12.10		29.90 ± 11.87		0.63	ns
AC	2.61 ± 2.67		2.63 ± 2.51		0.08	ns
log AC	0.2444 ± 0.4023	1.76	0.2223 ± 0.4898	1.67	0.53	ns
pH	6.72 ± 0.13		6.72 ± 0.13		0	ns
EC	4.32 ± 0.46		4.22 ± 0.49		2.28	*
AL	1.50 ± 0.92		1.41 ± 0.90		1.07	ns
SH	7.52 ± 0.89		7.62 ± 0.97		1.16	ns
TEC	103.5 ± 41.3		113.5 ± 52.1		2.28	*
RCQ	2.51 ± 0.96		2.35 ± 1.01		1.76	ns
RCF	16.48 ± 2.84		15.86 ± 3.56		2.07	*
WV	35.36 ± 3.36		34.61 ± 3.15		2.51	*
CP	3.30 ± 0.30		3.53 ± 0.31		8.17	***
CAS	2.62 ± 0.25		2.81 ± 0.28		7.70	***
TP	3.11 ± 0.29		3.33 ± 0.29		8.20	***
WP	0.50 ± 0.090		0.52 ± 0.100		2.27	*
NPN	0.19 ± 0.059		0.20 ± 0.064		1.75	ns
URN	49.00 ± 16.88		45.33 ± 17.33		2.32	*
F/CP	1.13 ± 0.273		1.23 ± 0.238		4.27	***
CN-CP	79.26 ± 2.74		79.57 ± 3.08		1.15	ns
CN-TP	84.03 ± 2.44		84.38 ± 2.91		1.40	ns

Statistical significance of differences: ns = $P > 0.05$; * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$; n = number of incidents, $x \pm sd$ = arithmetic mean ± standard deviation, xg = geometric mean, t = test criterion of t-test; Sign. = significance of the difference; NL = number of lactation; SL = stage of lactation

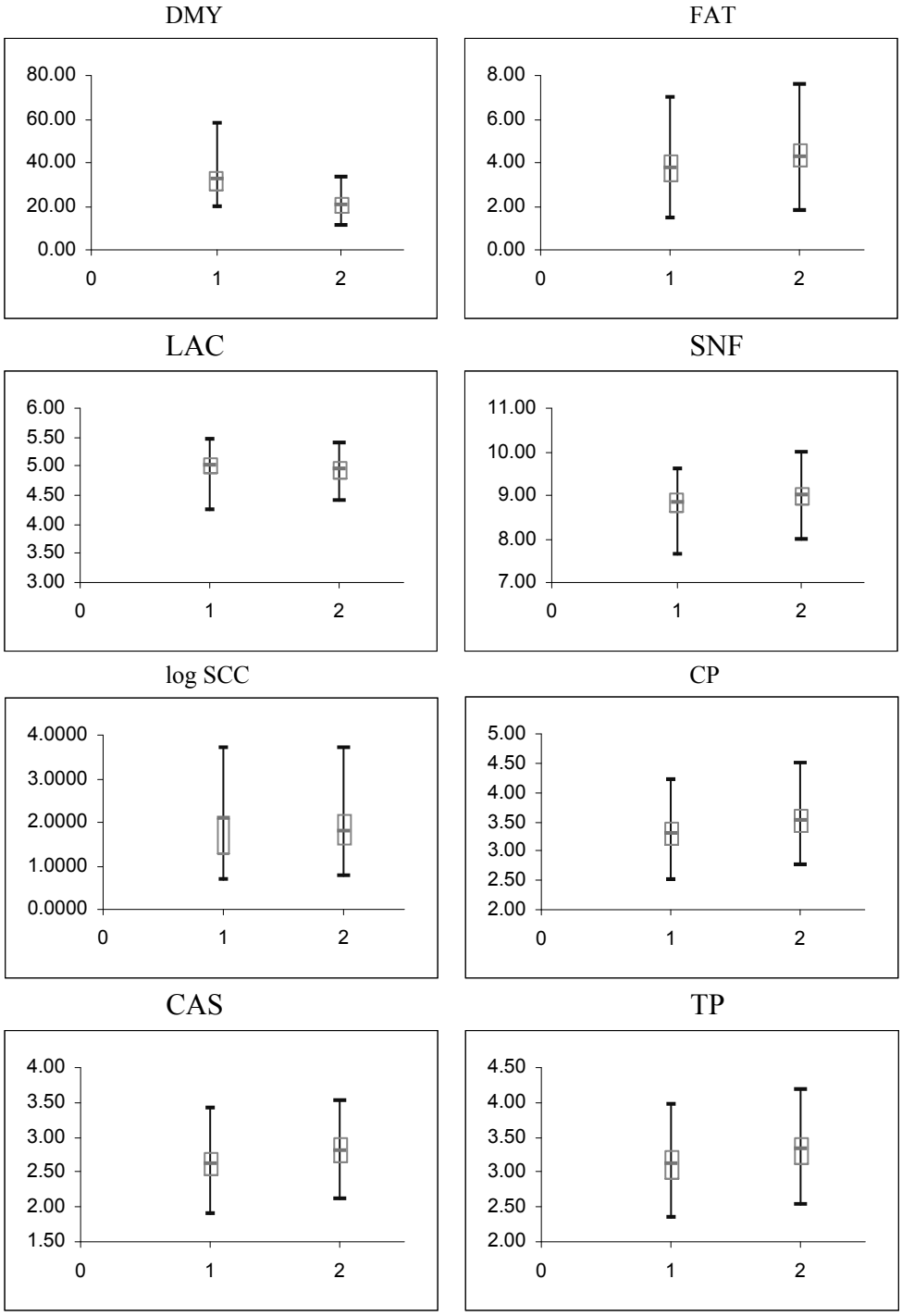

Fig. 1. Presentation of the main central statistical moments and characteristic of data frequency distribution for cases of significant differences in milk indicators between CF cows with high (1) and lower (2) MY
Construction of box graph: the file median (the central short horizontal line); the top edge of 1st and 3 rd quartile (the tetragon); the variation range as difference between maximum and minimum (the vertical line)

had statistically significant influence ($P \leq 0.001$; Table 2; Fig. 1) on the following milk indicators (MIs): fat; lactose; solids non fat; log somatic cell count; crude protein; casein; true protein; fat/crude protein ratio. Differences for $P \leq 0.001$ significance level were: fat content 0.62% (CF1 3.71 ± 0.89; CF2 4.33 ± 0.84; 14.32% relatively, CF2 is equal to 100%); LAC 0.08 (CF1 5.00 ± 0.21; CF2 4.92 ± 0.20; relatively 1.63%); SNF 0.14% (CF1 8.83 ± 0.35; CF2 8.97 ± 0.34; 1.56%); log SCC expressed as *xg* 24 10^3. ml^{-1} (CF1 50; CF2 74 $10^3.ml^{-1}$; 32.43%); CP 0.23% (CF1 3.30 ± 0.30; CF2 3.53 ± 0.31; 6.52%); CAS 0.19% (CF1 2.62 ± 0.25; CF2 2.81 ± 0.28; 6.76%); TP 0.22% (CF1 3.11 ± 0.29; CF2 3.33 ± 0.29; 6.61%); F/CP 0.10 (CF1 1.13 ± 0.273; CF2 1.23 ± 0.238; 8.13%).

The results confirmed higher LAC with MY increase (Table 2; Fig. 1). There is more intensive LAC synthesis along MY elevation. This fact is valid also along lactation curve where LAC is decreasing with days in milk. MY is

also reduced by mastitis and secretion disorder occurrence (Raubertas, Shook, 1982; Reneau, 1986; Wiggans, Shook, 1987; Reneau et al., 1988) and LAC is decreased simultaneously (Hanuš et al., 1992, 1993). LAC is also reduced by later paritis (Miglior et al., 2006), probably due to more subclinical mastitis cases during subsequent lactations. It could also be the reason for the higher risk of culling at a low percentage of lactose (Miglior et al., 2006) and vice versa. The log SCC was significantly lower in CF1 dairy cows. Of course, the higher milk production is usually in accordance with healthier dairy cows (Ali, Shook, 1980; Shook, 1982; Raubertas, Shook, 1982; Reneau, 1986; Wiggans, Shook, 1987; Reneau et al., 1988). It means, lower MY could be influenced by milk losses by higher occurrence of subclinical mastitis or other milk production disorders. However, this difference was relatively small and probably without practical impact.

It is clear that CF1 group had higher genetic potential and higher feedstuff consumption within herds. It was connected certainly with markedly higher MY in CF1. On the other hand, it was also linked with differences in main milk composition with advantages for lower MY. Significant differences between CF1 and CF2 in milk nitrogen fraction for CP, TP and CAS could be important for milk processing. These composition differences in consideration of MY are much higher in CF as compared to Holstein breed in our previous paper (Sojková et al., 2010). In general, high MY did not lead to aggravated milk quality, but lead to its lower technological recovery in CF.

The F/CP ratio as possible indicator of cow energy metabolism (Geishauser, Ziebell, 1995; Heuer et al., 1999, 2001) was also influenced significantly (Table 2) but in opposite direction as expected. It is similar to our previous results in Holstein (Sojková at el., 2010). It means that there were no serious problems with the subclinical ketosis occurrence in the sample (animal) sets. It is also confirmed by no significant difference between CF1 and CF2 and also by lower average AC values (Table 2; $P > 0.05$) as another indicator of cow energy metabolism (Andersson, Lundström, 1984a, b; Andersson, 1985; Gravert et al., 1986; Diekmann, 1987; Gustafsson, Emanuelson, 1993; Geishauser et al., 1997, 1998; Hanuš et al., 1999; Říha, Hanuš, 1999 b; Enjalbert et al., 2001; Mottram et al., 2002; Baticz et al., 2002; Wood et al., 2004; Bezdíček et al., 2009). The higher AC values were confirmed at body condition losses of cows in their first third of lactation during negative energy balance (Fig. 2).

Lower significant influence ($P \leq 0.05$; Table 2; Fig. 1) was observed on the following MIs: electrical conductivity; time for enzymatic coagulation (renneting ability); rennet curds firmness; whey volume after renneting; whey protein; ratio of urea nitrogen in the non protein nitrogen. These differences were as follows: EC 0.10 mS.cm^{-1} (CF1 4.32 ± 0.46; CF2 4.22 ± 0.49 mS.cm^{-1}; 2.37%); TEC 10.0 second (CF1 103.5 ± 41.3; CF2 113.5 ± 52.1 second; 8.81%); RCF 0.62 mm (CF1 16.48 ± 2.84; CF2 15.86 ± 3.56 mm; 3.91%); WV 0.75 ml (CF1 35.36 ± 3.36; CF2 34.61 ± 3.15 ml; 2.17%); WP 0.02% (CF1 0.50 ± 0.09; CF2 0.52 ± 0.10; 3.85%); URN 3.67% (CF1 49.00 ± 16.88; CF2 45.33 ± 17.33; 8.10%). Nevertheless, these facts have practically inexpressive impacts on technological milk quality.

Insignificant differences existed for next 9 MIs (acetone, urea, pH, titration acidity, alcohol stability, rennet curds quality, non protein nitrogen, casein numbers). Surprisingly, higher milk U as energy-protein metabolism indicator (Piatkowski et al., 1981; Ropstad, Refsdal, 1987; Butler et al., 1996; Larson et al., 1997; Říha, Hanuš, 1999a; Mottram et al., 2002; Pechová, 2000; Guo et al., 2004; Hojman et al., 2004; Zhai et al., 2006; Jílek et al., 2006; Miglior et al., 2006; Stoop et al., 2007; Kubešová et al.,

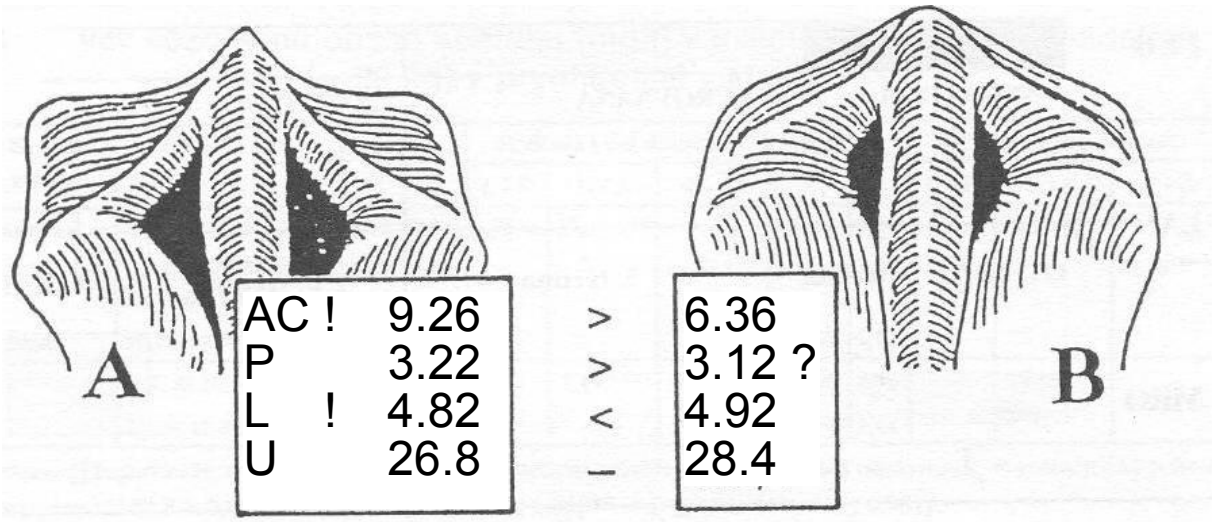

Fig. 2. Some interesting differences in composition of individual cow milk samples in the first third of lactation during large (A) and normal (B) loss of body condition score after calving – modified according to Webster (cit. Thomas, Warren, 1990) and Hanuš et al. (1999)
AC = acetone (mg.l^{-1}); P = protein (%); L = lactose monohydrate (%); U = urea (mg.100 ml^{-1})

2008; Bezdíček et al., 2009) was not linked with higher MY in CF breed. It is in accordance with our previous results in Holstein (Sojková et al., 2010) however in contrast to our previous papers (Hanuš et al., 2007; Janů et al., 2007). Probably the cows with higher genetic potential for MY (as CF1 group) have a better ability to utilize nitrogen matter from feeding ration under the same environmental conditions (identical herd) as compared to CF2 cows. In the connection Miglior et al. (2006) found a tendency for Ayrshire cows with high and low U concentration to be culled at a higher than average rate. Instead Holstein cows had a linear association, with decreasing relative risk of culling with increasing levels of U concentration.

CONCLUSIONS

Differences between the CF higher yielding group (characterized by higher degree of the animal genetical improvement in terms of MY level with higher feedstuff consumption and utilization) and the CF lower yielding group were significant mainly among parameters FAT, LAC, SNF, log SCC, CP, CAS and TP. Both groups produced milk, which corresponded to standard requirements on good milk quality. The differences in MIs between groups do not represent dairy cow health troubles. Also high MY did not lead to aggravated milk quality, but lead to its lower technological recovery. Differences within milk indicators between higher and lower milk yield were generally larger and more frequent in CF cows as compared to Holstein cows. These findings are in accordance with results of previous studies (Hanuš et al., 2007; Janů et al., 2007).

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Received for publication on November 22, 2009
Accepted for publication on April 21, 2010

SOJKOVÁ, K. – HANUŠ, O. – ŘÍHA, J. – YONG, T. – HULOVÁ, I. – VYLETĚLOVÁ, M. – JEDELSKÁ, R. – KOPECKÝ, J. (Výzkumný ústav pro chov skotu, Rapotín, Česká republika; Agrovýzkum Rapotín, Česká republika; Anhui Agricultural University, Hefei, Čínská lidová republika):

Srovnání vlivů fyziologie laktace při vysoké a nižší užitkovosti na složky, vlastnosti a zdravotní ukazatele mléka u českého strakatého plemene.

Scientia Agric. Bohem., *41*, 2010: 84–91.

Mléčná užitkovost (MY) je jednou z hlavních vlastností plemene skotu české strakaté (CF). Je zjišťována v rámci kontroly užitkovosti. MY je důležitým ekonomickým a zdravotním faktorem. Byly sledovány rozdíly v obsahu mléčných ukazatelů (MIs) mezi dvěma skupinami dojnic CF s vysokou (CF1; n = 213 individuálních vzorků mléka /zvířat/) a nižší (CF2; n = 265) užitkovostí. Skupiny sledovaných dojnic byly vyrovnány z hlediska fáze laktace, tedy počtu dnů od otelení. Skupina 1 byla podle fenotypu (MY) na vyšší genetické úrovni a měla tak podle MY i lepší výživu. Průměrná denní mléčná užitkovost CF1 byla o 56 % vyšší oproti CF2 ($P \leq 0{,}001$). Významné rozdíly ($P \leq 0{,}001$) byly určeny pro: tuk (FAT); laktózu (LAC); tukuprostou sušinu (SNF); log počtu somatických buněk (log SCC); hrubé bílkoviny (CP); kasein (CAS); čisté bílkoviny (TP); poměr tuk/hrubé bílkoviny (F/CP). FAT, LAC a SNF se lišily zřetelně tak, že dojnice CF1 měly nižší obsah FAT, LAC a SNF v porovnání k CF2 (3,71–4,33 %, 5,00–4,92 % a 8,83–8,97 %). Log SCC byl významně nižší u dojnic s vyšší MY (xg 50–74 $10^3.ml^{-1}$). U krav bez poruch zdraví byla zjištěna vyšší mléčná užitkovost. Rozdíl však byl poměrně malý. Skupina CF1 měla vyšší genetický potenciál i vyšší spotřebu krmiva uvnitř stád. Dále byly významné rozdíly mezi CF1 a CF2 u dusíkaté frakce mléka pro CP, CAS a TP (3,30–3,53 %, 2,62–2,81 % a 3,11–3,33 %). Další významné ($P \leq 0{,}05$) rozdíly byly u elektrické vodivosti (CF1 > CF2), času enzymatické koagulace (syřitelnost; CF1 < CF2), pevnosti sýřeniny (CF1 < CF2), objemu syrovátky po sýření (CF1 > CF2), bílkovin syrovátky (CF1 < CF2) a poměru dusíku močoviny v nebílkovinném dusíku (CF1 > CF2). Nevýznamné rozdíly existovaly pro dalších devět MIs (jako aceton, pH, titrační kyselost, alkoholová stabilita, kaseinové číslo). U plemene CF nebyla vyšší MY překvapivě spojena s vyšším obsahem močoviny v mléce. Rozdíly v MIs mezi CF1 a CF2 nepředstavují zdravotní problémy. Vysoká MY dosažená šlechtěním a efektivnější výživou nevedla ke zhoršené kvalitě mléka, ale k jeho nižší technologické výtěžnosti.

dojnice; české strakaté plemeno; mléčná užitkovost; složky mléka; zdravotní ukazatele v mléce; fyzikální a technologické vlastnosti

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