THE IMPORTANCE OF MONITORING CHANGES IN MILK FAT TO MILK PROTEIN RATIO IN HOLSTEIN COWS DURING LACTATION

VÝZNAM SLEDOVÁNÍ ZMĚN POMĚRU TUK/BÍLKOVINA V MLÉCE HOLŠTÝNSKÝCH DOJNIC

Vladimír ČEJNA*, Gustav CHLÁDEK

Department of Animal Breeding, Mendel University of Agriculture and Forestry in Brno, Zemědělská 1, 613 00 Brno, Czech Republic, Tel.: +420 545 133 220, e-mail: xcejnav@seznam.cz

Manuscript received: October 3, 2005; Reviewed: October 10, 2005; Accepted for publication: October 10, 2005

ABSTRACT

Milk samples of 24 pure-bred Holstein cows were taken during lactation and changes in milk fat to milk protein ratio and quality of rennet gel were evaluated. The cows were either first (n=12) or second (n=12) calvers, in the same phase of lactation. The individual milk samples were taken on average on the day 25, 45, 73, 101, 133, 166, 199, 224, 253 and 280 of lactation and the following mean values of the F/P ratio were found: 1.91; 1.45; 1.38; 1.28; 1.22; 1.14; 1.26; 1.21; 1.09; 1.18. High values in the first phase suggest a great energy deficiency. The quality of rennet gel was also worst in the first phase of lactation.

KEY WORDS: Holstein cattle, milk protein, milk fat, milk fat to protein ratio, quality of rennet gel

ABSTRAKT

V průběhu laktace byly odebírány vzorky od 24 čistokrevných holštýnských dojnic a hodnoceny změny poměru tuk/bílkovina a kvality sýřeniny. Dojnice se nacházely ve stejném počtu na první a druhé laktaci a byly ve stejném stádiu laktace. Odběr individuálních vzorků mléka probíhal v průměrném 25., 45., 73., 101., 133., 166., 199., 224., 253. a 280. dni laktace. Při jednolivých odběrech byly zjištěny tyto průměrné hodnoty poměru tuk/bílkovina: 1,91; 1.45; 1,38; 1,28; 1,22; 1,14; 1,26; 1,21; 1,09; 1,18. Vysoké hodnoty v první třetině laktace naznačují velký energetický deficit. V první třetině laktace byla též zjištěna nejhorší kvalita sýřeniny.

KEY WORDS: holštýnský skot, mléčná bílkovina, mléčný tuk, poměr tuk/bílkovina, kvalita sýřeniny

DETAILED ABSTRACT

V důsledku narůstající mléčné užitkovosti holštýnských dojnice se zvyšují nároky na zabezpečení optimálního přísunu živin. Nedostatky ve výživě dojnic dávají předpoklad vzniku metabolických poruch, které se mohou projevit ve složení a vlastnostech mléka. Pro posouzení výživy, konverze živin a metabolismu je důležité sledovat poměr obsahu tuku a bílkovin. Za optimální lze považovat poměr T/B = 1,2 – 1,4. Při klesající hodnotě tohoto koeficientu lze předpokládat nástup subklinických acidóz bachorového obsahu, vysokou acidogenní zátěž vnitřního prostředí, ohrožení reprodukční výkonnosti dojnic a nebezpečí vzniku poruch minerálního metabolismu. Zvýšení kvocientu nad 1,4 signalizuje energetický deficit a při nálezu ketolátek subklinickou ketózu [7]. Také Richardt [15] uvádí, že poměr T/B vyšší než 1,5 může signalizovat podezření na subklinickou ketózu, a naopak, při kvocientu menším než 1,1 je reálné podezření na bachorovou acidózu.

S cílem analyzovat vliv stádia laktace na obsahové složky mléka a jeho technologické vlastnosti byly odebírány individuální vzorky mléka (celodenní nádoj) od 24 čistokrevných holštýnských dojnic ŠZP v Žabčicích. Dojnice se ve shodném počtu nacházely na první a druhé laktaci a byly ve stejném stádiu laktace. Odběr individuálních vzorků mléka probíhal 10x po dobu 280 dnů laktace a to v průměrném 25., 45., 73., 101., 133., 166., 199., 224., 253. a 280. dni laktace. Obsahové složky byly stanoveny pomocí infračerveného absorpčního analyzátoru (Bentley 2000). Technologické vlastnosti mléka byly zjišťovány v laboratoři Ústavu chovu a šlechtění zvířat. Kvalita sýřeniny byla hodnocena po 60 minutové inkubaci 100 ml zasýřeného mléka v Erlenmayerových baňkách (o objemu 100 ml) při 35 °C a posouzena dle Tab 2, v níž se sleduje vzhled sýřeniny a syrovátky. Hodnocení bylo provedeno po vyklopení sýřeniny na Petriho misku.

Změny poměru T/B, obsahu tuku, bílkovin a kvality sýřeniny v mléce v průběhu laktace jsou uvedeny v grafu 1 a tabulce 3. V první třetině laktace se poměr T/B pohyboval v intervalu od 1,45 až 1,91. Tyto hodnoty naznačují velký energetický deficit, typický pro tuto fázi laktace. Z grafu 2, vyjadřující procentuální zastoupení případů v rozmezí poměru T/B 1,2-1,4, popř. ležících nad nebo pod tímto intervalem vyplývá, že s postupujícím stádiem laktace ubývá případů nacházejících se nad poměrem 1,4, a naopak, přibývá případů nacházejících se pod poměrem 1,2. Poměr T/B se do příznivějších hodnot dostává od začátku druhé třetiny laktace. Příznivé hodnoty však vykazuje pouze průměr, zatímco individuální vzorky vykazují velké rozdíly (viz min a max). V první třetině laktace byla zjištěna nejhorší kvalita sýřeniny. S postupujícím stádiem laktace docházelo k jejímu zlepšování. Sledování poměru tuk/bílkovina má tedy svůj význam a umožní kontrolu nad možnými chovatelskými nedostatky, které jsou zejména ve výživě dojnic,

INTRODUCTION

An increasing milk yield of Holstein cows has induced publication of numerous scientific papers on nutrition of cows and metabolic disorders. Metabolic disorders can be reflected in chemical-technological characteristics of milk and thus we looked into the changes of milk fat and protein content in individual milk samples of Holstein cows during lactation and the changes of their mutual ratio which can suggest nutritional deficiencies. At the same time, we monitored changes in the quality of rennet gel.

In order to evaluate nutrition, conversion of nutrients and metabolism it is important to study milk fat to milk protein ratio. The optimum F/P ratio is 1.2 – 1.4. Lower values are likely to lead to subclinical rumen acidosis which can endanger reproduction performance of cows and enhance a possible development of mineral metabolism disorders. The F/P ratio higher than 1.4 signals energy deficit and subclinical ketosis if ketone bodies are present [7]. Richardt [15] confirms that the F/P ratio higher than 1.5 can indicate subclinical ketosis whereas the F/P ratio lower than 1.1 can mean suspected rumen acidosis.

Also, the quality of milk from cows with metabolic disorders is impaired. In subclinical cases it is impossible to exclude the milk of sick cows from the tank (unlike milk of cows suffering from subclinical mastitis) which is therefore also sent to dairy where it can spoil the quality of milk processing [8]. Milk with a higher content of ketone bodies has a bitter taste and burns during heat processing [12]. Richardt [15] points out that F/P ratio is useful only when monitored in individual milk samples, not in pool samples. Official milk recording data provide a rough picture of the herd situation (milk yield, milk components) and indicate nutritional status of animals regarding energy, protein, fibre and starch supply. In high-producing herds we need considerably more information on milk production of the herd, and individual cows in particular.

Ketosis occurs when fat deposits are degraded due to a lack of energy. Such low energy levels can arise in post-parturient cows due to their increasing milk yield [9]. Ketosis develops especially in high-producing cows; it is of a creeping nature and lasting course [17].

Subclinical ketosis is associated with losses in milk

production and increased risk of periparturient disease. Prevention depends on several factors, including proper transition-cow nutrition management of body condition (BCS), and the use of certain feed additives such as niacin, propylene glycol, and ionophores [2].

Rajala-Schultz et al. [14] found a significant negative effect of ketosis on milk yield. Gillund et al. [6] confirmed the importance of BCS monitoring; ketotic cows had higher BCS at calving and during the first weeks postpartum than healthy cows, and ketotic cows lost significantly more body condition over a prolonged period of time compared with nondiseased cows.

Approximately 90 % of all ketosis case, clinical or subclinical or treatments occur within approximately 60 days postcalving. Incidence of ketosis increases with age and peak incidence may be in cattle in lactations 3 – 6. Cows with ketosis have a greater risk of developing displaced abomasum, infections of the reproductive tract, mastitis, cystic ovarian disease, diseases of the digit and foot and leg problems and repeat breeding [16].

Ketosis increases concentration of acetone, acet-acetic acid and β-hydroxy-butyric acid in various body fluids [1].

Ketosis can be indicated by an analysis of acetone content and also by F/P ratio (see Table 1). It is advisable to supplement these methods with BCS during lactation and to prevent an excessive fat deposition at the end of lactation by appropriate nutrition [9].

MATERIALS AND METHODS

With the aim of assessing the effect of phase of lactation on milk components and technological characteristics, the milk of 24 pure-bred Holstein cows was individually sampled (daily milk yield) in the university farm herd in Žabčice. The cows were divided into two equal groups (first and second calvers) and were in the same phase of lactation. The milk samples were taken ten times during the course of 280 days, on average on day 25, 45, 73, 101, 133, 166, 199, 224, 253 and 280 of lactation. The samples of milk which was excluded from the delivery to the dairy were not analysed. A total of 204 samples were analysed. Analysis was carried out in the LRM Brno-Chrlice laboratory using infrared absorption analyser (Bentley 2000). Technological characteristics of milk were tested in the laboratory of the Department of Animal Breeding of MUAF. The quality of rennet gel was assessed after a 60-minute incubation of 100 ml of coagulated milk (in 100 ml Erlenmayer retort) at a temperature of 35°C and was evaluated according to Table 2, which describes the visual aspect of gel and whey. The evaluation took place after tipping the gel out onto Petri dishes. Rennet Laktochym 1:5000 (Milcom Tábor, CR) was diluted 1:4 and added to the milk in the proportion of 2 ml per 100 ml milk for coagulation. Statistical analyses were carried out using a computer programme Statistica 6.

RESULTS AND DISCUSSION

Changes in the F/P ratio, milk fat content, milk protein content and quality of rennet gel during lactation are presented in Table 3 and Figure 1. In the first third of lactation the F/P ratio ranged between 1.45 and 1.91. These values suggest a great energy deficiency, typical for this phase of lactation. This corresponds with results

Table 1: Practical implications of milk fat to protein ratio [9]
Tabulka 1: Praktická interpretace poměru T/B v mléce [9]

With regards to the physiology of nutrition of cows (individual milk samples)			
	low F/P	suitable F/P	high F/P
Holstein cows	<1.05	1.05 - 1.18	>1.18
Dual purpose and dairy breeds (Germany)	<1.10 (lack of structural fibre in diet)	1.10 - 1.60	>1.60 (lack of energy, risk of ketosis)
With regards to cheese-making (tank or tanker milk samples)			
Milk in general (France)	<1.10	1.10 - 1.20 (the best technological value)	>1.20

Table 2: The evaluation of the quality of rennet gel [4]
Tabulka 2: Hodnocení kvality sýřeniny [4]

Quality class	Visual aspect of gel and whey
I	Gel is very good, firm, after tipping out keeps shape. Whey is clear, of yellow-green color.
II	Gel is good, less firm, worse keeps shape. Whey is not expelled ideally, it is of a whitish, greenish colour.
III	Gel is poor, soft, partly does not keep shape. Whey is of a milk-white colour.
IV	Gel is very poor, does not keep shape. Whey is of a milk-white colour.
V	No evident coagulation of casein.

of Frydrych [3] who determined that energy intake after parturition is nearly always lower than energy requirements. Thus, a negative energy balance (NEB) is typical for the first phase of lactation, associated with a high ratio between growth hormone and insulin in blood which induces mobilisation of long-chained fatty acids from fatty tissue. Appropriate measures to correct this negative status should be immediately taken at detection of such values.

Richardt [15] considers the F/P ratio to be a very important indicator of animal health. Its high values (above 1.5) in dairy cows signify a 1.5 times higher probability of incidence of mastitis, 7.5 times higher tendency towards lameness and 3.5 times higher incidence of ketosis. According to Trajlinek [18] the presence of ketosis in a herd brings about enormous economic loss. Apart from a negative impact on reproduction it also negatively affects milk production and enhances development of other diseases such as displacement of abomasum and liver steatosis.

Figure 2 presents the percentage of the F/P ratio lower than 1.2, higher than 1.4 and ranging between 1.2 and 1.4; the graph shows that the incidence of the F/P ratio higher than 1.4 decreases and the incidence of the F/P ratio lower than 1.2 increases during lactation. At the beginning of the second phase of lactation the mean values of the F/P ratio become more favourable, however, individual samples show great differences (see min and max values).

Values from the second and third phase of lactation may suggest possible outset of subclinical acidosis. According to Nocek [13], subclinical acidosis manifests in a low or changeable feed intake, a lower milk production, a lower BCS (despite an adequate energy intake), a higher culling rate, unexplained diarrhoea, higher incidence of laminitis and a lower milk fat content. Our results also showed lower milk fat content (see Figure 1) during that period (day 166 and 253). Subclinical acidosis occurs both at the beginning of lactation when the cow is getting used to new diet composition, and in late lactation due to the incorrect calculation of feed intake, an inaccurate proportion of fibre and concentrated feed, inadequate fibre structure and incorrectly prepared TMR (Total Mixed Ration) [11]. The appropriate F/P ratio for Holstein cows is 1.05 -1.18 (Table 1).

High values of milk fat content (5.49%) at the beginning of lactation (day 25) suggest possible degradation of body fat deposit. According to Gajdůšek [5], a non-physiological increase in milk fat content was found in individual milk samples in milk recording. This occurs due to a negative energy balance in cows, especially at the beginning of lactation when cows degrade their fat deposits which might otherwise increase milk fat content.

Chládek [10] points out that a milk recording sheet provides information not only on milk yield, but also on milk fat, milk protein and lactose content. Analysis of milk components content offers a wide range of important data which are helpful in a prompt adjustment of nutrition or in a herd breeding programme.

The changes in the quality of rennet gel are shown in Figure 3. Linear tendency suggests an increase in the quality of rennet gel (class I = best, class V = worst) during lactation. The worst quality of rennet gel, similar to the highest values of F/P ratio, was found in the first phase of lactation. However, the quality of rennet gel is affected by many other factors, such as milk acidity and the content and proportion of various forms of Ca and P.

Milk protein content increased almost linearly during lactation.

CONCLUSIONS

Our study confirmed that the F/P ratio changes during lactation and revealed high values of this ratio at the beginning of lactation in the observed herd. The quality

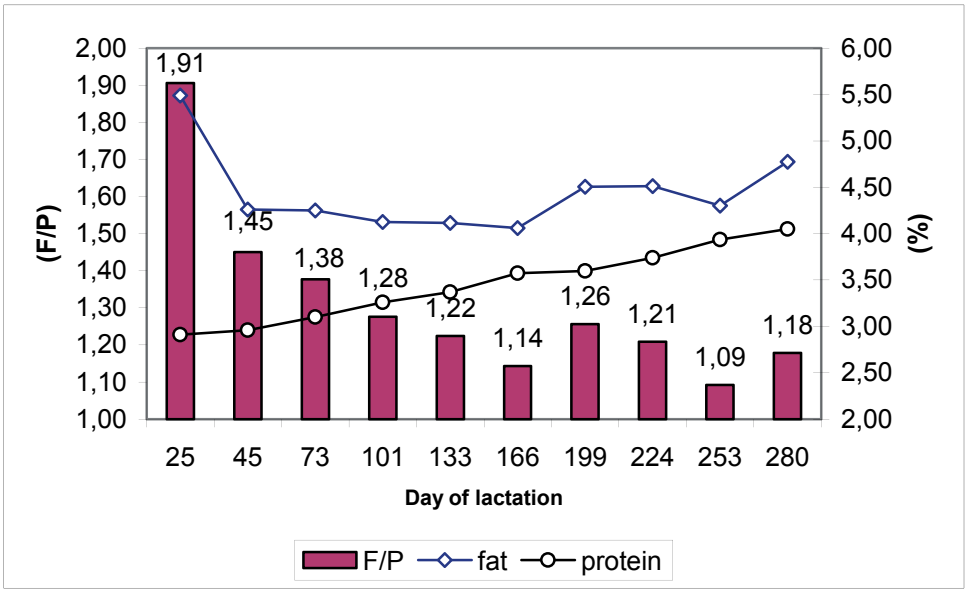

Figure 1: Changes in F/P ratio and milk fat and protein content during lactation
Obrázek 1: Změny poměru T/B a obsahu tuku a bílkovin v průběhu laktace

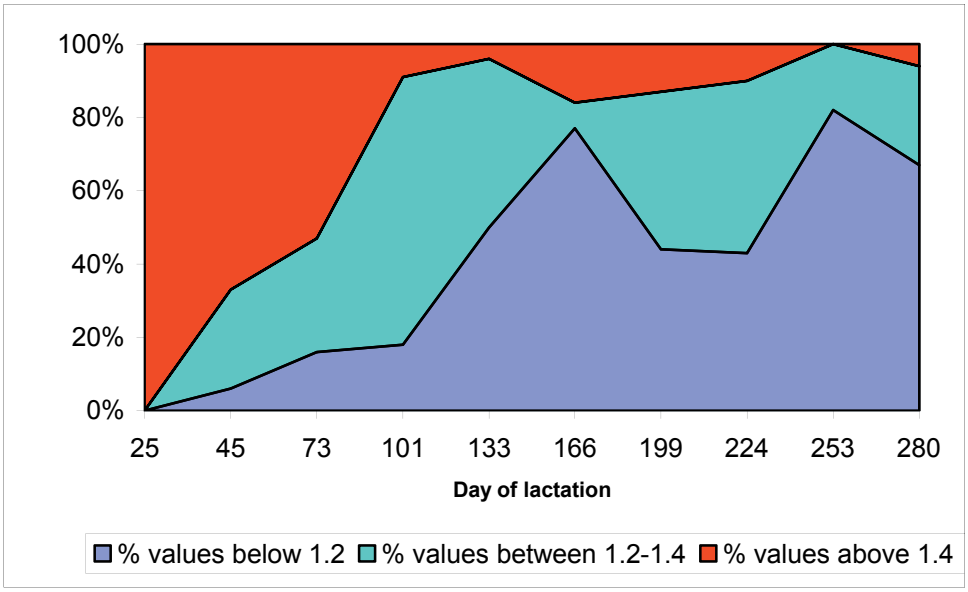

Figure 2: Proportion of values lower than 1.2, ranging between 1.2-1.4, and higher than 1.4
Obrázek 2: Procentuální vyjádření případů ležících v rozmezí 1,2-1,4, popř. nad nebo pod tímto intervalem

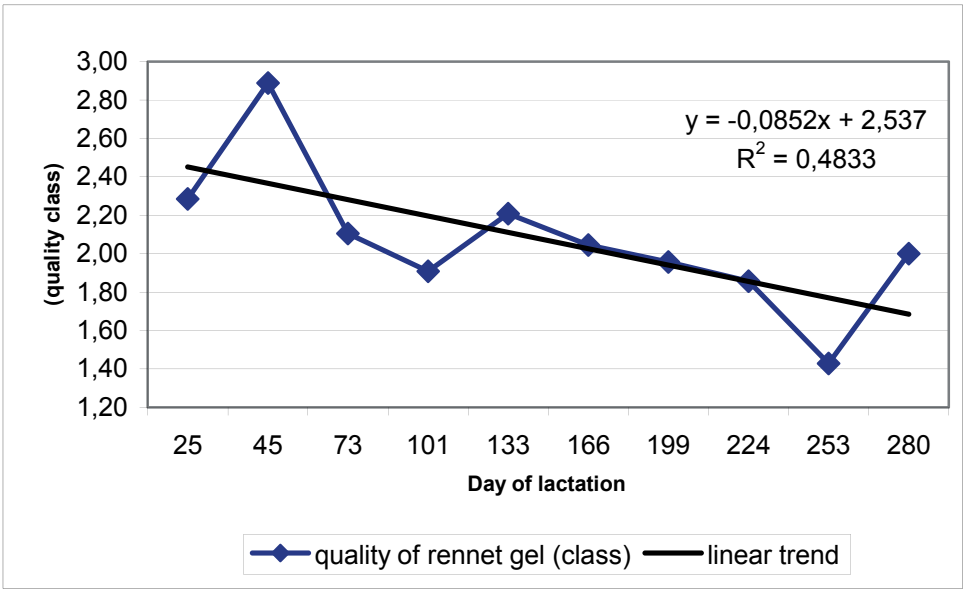

Figure 3: Changes in the quality of rennet gel during lactation

Obrázek 3: Změny kvality sýřeniny v průběhu laktace

of rennet gel was also impaired in that period. Therefore, monitoring of the F/P ratio is relevant for correcting and adjusting possible nutritional deficiencies in cows. Prompt precautions can effectively eliminate detrimental effects of negative energy balance. Individual milk fat and protein content data can be very easily obtained from milk recording sheets. Regular body condition scoring of cows should not be omitted.

ACKNOWLEDGEMENTS

The study was supported by MSM 432100001

REFERENCES

[1] Baticz, O., Tömösközi, S., Vida, L.: Concentrations of citrate and ketone bodies in cow's raw milk. Periodika polytechnica ser. Chem. eng. (2002), vol. 46, No. 1 -2: 93 - 104

[2] Duffield, T.: Subclinical ketosis in lactating dairy cattle. Vet. Clin. North Am. Food Anim Pract. (2000) Jul;16(2):231-53

[3] Frydrych, Z.: Nutrition of cows in dry period. (in Czech) The breeding 11/2004: 20 –P23

[4] Gajdůšek, S.: Dairying II. (in Czech) Brno: MZLU. 1999

[5] Gajdůšek, S.: Dairy science. (in Czech) Brno: MZLU. 2003

[6] Gillund, P., Reksen, O., Gröhn, Y. T., Karlberg, K.: Body condition related to ketosis and reproductive performance in Norwegian dairy cows. J. Dairy Sci. (2001), 84:1390–1396

[7] Haas, D., Hofírek, B.: The diagnostic importance of milk components for a human and cows' health. (in Czech) CUA Prague, Proceedings of contributions: Milk day 2004. 26 – 29

[8] Hanuš, O. et al.: The monitoring of body condition, health and nutrition of cows and the improvement of their reproduction. (in Czech) DAFI 3/2004, 2004a

[9] Hanuš, O. et al.: The impact of laboratory testing of raw cow milk for the breeders. (in Czech) Dairying 2/2004 (35), 2004b, 31 – 38

[10] Chládek, G.: Milk composition as a cheap and effective means for evaluation of breeding conditions of lactating cows. (in Czech) RIFCB, Ltd., Rapotín, Proceedings of contributions: The actual problems of management in the cattle keeping. 2004, s. 56 – 61

[11] Kleen, J. L., Hooijer, G. A., Rehage, J., Noordhuizen, J. P. T. M.: Subacute ruminal acodosis (SARA): a review. Journal of Veterinary Medicine Series a, Physiology, Pathology, Clinical Medicine. (2003), 50 (8): 406-414

Table 3: Changes and variability of F/P ratio and mean values of milk fat and protein content and quality of rennet gel during lactation
Tabulka 3: Změna a variabilita poměru T/B a průměrné hodnoty obsahu tuku, bílkovin a kvality sýřeniny v průběhu laktace

Day of lactation		*25*	*45*	*73*	*101*	*133*	*166*	*199*	*224*	*253*	*280*
F/P ratio	n	14	18	19	22	24	24	23	21	21	18
	$\bar{x}$	1.91	1.45	1.38	1.28	1.22	1.14	1.26	1.21	1.09	1.18
	Sx	0.287	0.144	0.191	0.213	0.121	0.170	0.171	0.145	0.091	0.122
	v%	15.03	9.96	13.88	16.70	9.92	14.89	13.59	12.03	8.32	10.35
	min	1.48	1.16	0.97	0.94	0.99	0.91	1.04	0.91	0.97	0.91
	max	2.31	1.75	1.65	2.09	1.56	1.59	1.86	1.48	1.28	1.41
	% values between 1.2-1.4	0	27	31	73	46	7	43	47	18	27
	% values above 1.4	100	67	53	9	4	16	13	10	0	6
	% values below 1.2	0	6	16	18	50	77	44	43	82	67
Milk fat	(%)	5.49	4.26	4.25	4.13	4.12	4.06	4.50	4.51	4.30	4.77
Milk protein	(%)	2.91	2.96	3.10	3.26	3.37	3.58	3.60	3.74	3.94	4.05
Gel quality	(Class)	2.29	2.89	2.11	1.91	2.21	2.05	1.96	1.86	1.43	2.00

[12] Kudrna, V. et al.: Feed production and cattle nutrition. (in Czech) Agrospoj Prague. 1998

[13] Nocek, J. E.: Bovine acidosis: implications on laminitis. J. Dairy Sci. (1997), 80:1006-1028

[14] Rajala-Schultz, P. J., Gröhn, I. T., Mc Culloch, C. E.: Effects of milk fever, ketosis and lameness on milk yield in dairy cows. J. Dairy Sci. (1999), 82:288–294

[15] Richardt, W.: Milk composition as an indicator of nutrition and health. (in Czech) The Breeding 11/2004, 26 –27

[16] Roginski, H., Fuquay, J. W., Fox, P. F.: Encyclopedia of dairy science. Academic Press, 2002,

[17] Skyva, J.: A breeding and economic impact of milk analyses for ketone bodies, somatic cells and urea, including elaboration of advisory sheet. (in Czech) RIFCB, Ltd., Rapotín, Proceedings of contributions: The actual problems of management in the cattle keeping. 2004, 62 – 67

[18] Trajlinek, J.: Nutrition at dairy cows with high milk yield in relationship to diseases which are in connection with ketosis. (in Czech) RIFCB, Ltd., Rapotín, Proceedings of contributions: Breeding, nutritional and technological aspects of milk production and quality. 2000, s. 75 – 78