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The comparison of milk production and quality in cows from conventional and automatic milking systems

Porovnání produkce a kvality mléka v dojírně a systému AMS

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Abstract

The objective of this study was to evaluate the effects of two different types of milking systems (conventional parlour vs. automatic milking system) and the season of the year on the composition and hygienic quality of milk from Czech Fleckvieh cows. A total of 500 cows were involved; 200 and 300 in conventional and automatic milking systems, respectively. Bulk milk samples were collected for 12 months from July 2010 to June 2011. The following milk components and quality indicators were determined: % of fat, % of protein, % of lactose, % of fat-free dry matter (FFDM), % of casein, urea content, somatic cell count (SSC), total germ count (TGC) and milk freezing point (FP). The data were processed and evaluated with MS Excel and the statistical software SAS 9.1. Significantly higher (P<0.05 – 0.01) contents of fat, protein, FFDM and casein and increased TGC were observed in the automatic milking system, whereas SCC and FP were significantly lower (P<0.01). The highest contents of fat, protein and casein, and the lowest lactose content were found in the winter season. The highest contents of FFDM, urea and SCC were observed in autumn, whereas TGC was highest in summer (P<0.05 – 0.01). Only FP was not influenced by the season.

Keywords: Czech Fleckvieh cows, milk components, milking system, quality indicators, season

Abstrakt

Cílem této práce bylo vyhodnotit vliv dvou rozdílných způsobů dojení krav českého strakatého plemene (n=200; resp. 300 kusů) (dojírna, dojící robot) a období roku na obsah vybraných složek mléka a ukazatelů hygieny, resp. jeho kvality. Odběry směsných bazénových vzorků mléka probíhaly po dobu 12 měsíců, v rozmezí července 2010 až června 2011. Hodnoceny byly následující obsahy složek mléka a ukazatelé kvality: % tuku, % bílkovin, % laktózy, % tukuprosté sušiny (TPS), %

kaseinu, obsah močoviny, počet somatických buněk (SB), celkový počet mikroorganismů (CPM) a bod mrznutí mléka (BMM). Získaná data byla převedena do programu MS Excel a vyhodnocena pomocí statistického programu SAS 9.1. Ve stáji s dojením za pomoci dojících robotu byl zjištěn průkazně (P<0,05 – 0,01) vyšší % obsahu tuku, bílkovin, TPS, kaseinu a CPM. Naopak průkazně (P<0,01) nižších hodnot v této stáji bylo dosaženo v ukazatelích počtu SB a BMM. Při hodnocení efektu období roku byly stanoveny statisticky průkazně (P<0,01) nejvyšší hodnoty % obsahu tuku, % bílkovin a % kaseinu v zimním období roku. V tom samém období byla naopak sledována nejnižší hodnota % obsahu laktózy. Dále nejvyšší % obsah TPS, močoviny a počet SB byl pozorován v podzimním období roku a nejvyšší obsah CPM (P<0,05 – 0,01) byl vypočten pro letní období roku. Pouze u BMM nebyly zaznamenány žádné tendence a průkazné rozdíly.

Klíčová slova: český strakatý skot, složky mléka, system dojení, indikátory kvality, období

Detailed abstract

Dojení pomocí dojícího robota začíná být v poslední době poměrně rozšířený způsob získávání mléka od krav. Využívání robotů má určité výhody (zvýšení produkce, snížení počtu somatických buněk apod.), ale také nevýhody (snížení obsahu složek, pořizovací cena a další).

Cílem této práce bylo proto vyhodnotit vliv dvou rozdílných způsobů dojení krav českého strakatého plemene (n=200; resp. 300 kusů) (dojírna, dojící robot) a období roku na obsah vybraných složek mléka a ukazatelů hygieny, resp. jeho kvality.

Průměrná mléčná užitkovost hodnocených stájí byla 6870 kg/kráva/laktace. Zvířata v obou stájích byla krmena směsnou krmnou dávkou (TMR) složenou z jetelotravní siláže, kukuřičné siláže, mláta, sena a koncentrátu (dle aktuální produkce mléka). Odběry směsných bazénových vzorků mléka probíhaly 2 až 4 krát měsíčně po dobu 12 měsíců, v rozmezí července 2010 až června 2011. Hodnoceny byly následující obsahy složek mléka a ukazatelé kvality: % tuku, % bílkovin, % laktózy, % tukuprosté sušiny (TPS), % kaseinu, obsah močoviny, počet somatických buněk (SB), celkový počet mikroorganismů (CPM) a bod mrznutí mléka (BMM). Získaná data byla převedena do programu MS Excel a vyhodnocena pomocí statistického programu SAS 9.1. Pro detailní vyhodnocení byla použita procedura MEANS, CORR a GLM. Modelová rovnice pro vyhodnocení obsahovala efekt stáda (dojírna, nebo dojící robot) a efekt sezóny odběru vzorků mléka.

Ve stáji s dojením za pomoci dojících robotu byl zjištěn průkazně (P<0,05 – 0,01) vyšší % obsahu tuku, bílkovin, TPS, kaseinu a CPM. Naopak průkazně (P<0,01) nižších hodnot v této stáji bylo dosaženo v ukazatelích počtu SB a BMM. Při hodnocení efektu období roku byly stanoveny statisticky průkazně (P<0,01) nejvyšší hodnoty % obsahu tuku, % bílkovin a % kaseinu v zimním období roku. V tom samém období byla naopak sledována nejnižší hodnota % obsahu laktózy. Dále nejvyšší % obsah TPS, močoviny a počet SB byl pozorován v podzimním období roku a nejvyšší obsah CPM (P<0,05 – 0,01) byl vypočten pro letní období roku. Pouze u BMM nebyly zaznamenány žádné tendence a průkazné rozdíly.

Introduction

The beginnings of automatic milking are dated back to the 1970's (Rabold et al., 2002). The most rapid development of automatic milking systems (AMS) took place in the Netherlands and the first independent robot was installed in 1992 (Havlík, 2007). Due to ever growing milk production, the AMS technology was also adopted in the Czech Republic. The first milking robot was installed in the Czech Republic in 2003. Of 102 robots installed in 2009, the most frequently used type was Lely Astronaut installed in 35 farms (Machálek, 2009). Family farms may benefit from adopting milking robots with the aim to use labour time more efficiently, improve farm working conditions and substitute equipment for human labour (Rotz et al., 2003). The main advantage of the AMS is an increased daily milk yield as a result of a higher milking frequency. In addition, more frequent milking is associated with a reduced SCC. However, frequent milking and modified intervals between milking events may also lead to deteriorated milk quality (Rabold et al., 2002). As reported by Kvapilík (2005), milk quality is not negatively influenced to a great extent by robotic milking; however, SCC and TGC in 1 ml of milk can be increased. The AMS has the potential to increase milk production by 5 – 15 %. However, positive results of robotic milking are ambiguous. Of ten German farms equipped with the AMS, seven increased milk production by 900 kg of milk per lactation on average, two decreased milk yields and no change was observed in one herd, whereas milk composition was affected in none of these herds (Wirtz et al., 2003). Spolders (2002) reported that the milk production increase by 3 – 20 % was associated with the milking frequency 3 – 4 times a day. On the other hand, more frequent milking results in fat content reductions both in conventional and automatic milking systems. Positive effects of a higher frequency of milking were detected in cows with daily milk yields above 35 kg (increase up to 18.9 %) compared to those with the milk yield of 25 kg (increase only 1.4 %), and thus, the advantages of more frequent milking were demonstrated only in cows with the milk production higher than 9500 kg per lactation (Doležal, 2000). Robotic milking resulted in 2.4 % higher milk production and 58 % higher SCC compared to the conventional parlour (Davis and Reinemann, 2000). Under experimental conditions, more frequent milking together with optimum nutrition may increase milk production by 15 – 20 %. However, 5 % increase is considered reasonable under common farm conditions (Meskens et al., 2001). More frequent milking results in a lower intra-udder pressure and thus it may affect cow's behaviour and extend the lying period (Sonck, 1996). Reduced intervals between milking events also provide less time necessary for the multiplication of microorganisms causing mastitis (Spahr et al., 1997). Lehnert (2004) compared the results of 494 herds with robotic milking. The installation of robots resulted in 5 % increase of milk production but also in deteriorated milk quality, especially increased TGC and SCC. However, the effects of robots on milk production, composition and quality of milk (SCC, TGC and metabolite contents) are generally ambiguous. Most studies indicate that robotic milking in comparison with conventional parlours increased milk production by 5 to 15 % with no marked modification of milk composition. However, some milk quality characteristics like SCC or TGC can be temporarily deteriorated (Kvapilík, 2005).

Milk composition is affected by a number of factors, such as genetics (Hanuš et al., 2011a), nutrition (Buttchereit et al., 2011), cow's energy status (Friggens et al., 2007), season (Auldist et al., 1998; Lujerdean et al., 2009), and others (age, parity, ambient temperature).

Two types of milking systems (milking robot and herringbone parlour) located in a single farming enterprise were compared. We hypothesised that robotic milking will result in higher milk yields but lower contents of milk components and less SCC and TGC. The main objective of this study was to determine the effect of a milking system on total milk yield, contents of milk components (fat, protein, lactose, fat-free dry matter, casein) and milk quality parameters (urea content, SCC, TGC, FP). We also analysed the effect of season on the parameters mentioned above.

Materials and Methods

Animals

A total of 500 Czech Fleckvieh cows were located in two separate stables equipped with different milking systems. The average milk production was 6870 kg. Only slight differences between animals existed in breeding values. In Stable 1, 200 cows were loose housed in straw-bedded cubicles and fed a total mixed ratio (TMR). The diet consisted of 17 kg of clover-grass silage, 17 kg of maize silage and 4 kg of draff per cow and day. In addition, 250 g of concentrates per 1 kg of milk and 1 kg of hay per cow and day were also provided. The animals were milked twice a day in a 2 x 8 herringbone parlour. In Stable 2 for 300 cows, cubicle floors were covered with rubber mattresses. The composition of TMR was the same as for the animals in Stable 1, only the concentrates were supplemented in the amount of 1.3 kg per cow per day. Lely Astronaut A3 robots were used for milking and feeding 250 g of concentrates per 1 kg of produced milk, similarly as in Stable 1. The system was put into operation in July 2008. The frequency of milking is rather individual with the maximum frequency set at 3 milkings per day. The average milking frequency ranged from 2.2 to 2.3 milkings per day. Heated water troughs were used to supply water in both stables.

Collection of samples and analyses

Bulk milk samples were collected 2 to 4 times a month for a total of 12 months from July 2010 to June 2011. The following milk components and quality indicators were determined: % of fat, % of protein, % of casein, % of lactose, % of fat-free dry matter (FFDM), somatic cell count (SSC), total germ count (TGC) and milk freezing point (FP). Milk samples (n=78) were analysed in a laboratory accredited for milk analyses. The price of milk was set on the basis of milk analysis results. The proportion of non-standard milk was also recorded.

Statistical evaluation

The data were processed with MS Excel and the statistical software SAS 9.1. (SAS/STAT® 9.1., 2004). The MEANS procedure was used to calculate descriptive statistics for the traits evaluated. The CORR procedure was applied to calculate Pearson correlation coefficients for normal data distribution with the aim to evaluate the relationships between milk components and milk quality indicators. The effects of stable (milking system) and season on milk component contents and milk quality indicators were determined using the GLM procedure. Two different types of milking systems (1 – conventional parlour vs. 2 – milking robot) and four seasons of the year (1 - March to May, 2 - July to August, 3 – September to November, 4 – December to February) were evaluated. The differences between least square means were tested using Tukey-Kramer method. The following model equation was used:

$Y_{ijk}=\mu + HERD_i + SEASON_j + e_{ijk}$

where:

Y_{ijk} = dependent variables (fat (%), protein (%), lactose (%), FFDM (%), FP (^oC), casein (%), urea (mmol*l), SCC (x1,000*ml), TGC (x1,000*ml));

μ = mean value of dependent variable;

$HERD_i$ = fixed effect of i^{th} stable (i = 1, n = 38; i = 2, n = 40);

$SEASON_j$ = fixed effect of j^{th} season (j = 1 – March to May, n = 18; j = 2 – June to August, n = 20; j = 3 – September to November, n = 18; j = 4 – December to February, n = 22);

e_{ijk} = random error

Significance levels P<0.05, P<0.01 and P<0.001 were used to evaluate the differences between groups.

Results and Discussion

Descriptive statistics of the traits evaluated (contents of fat, protein, casein, lactose, fat-free dry matter, urea, somatic cell count, total germ count, and milk freezing point) are presented in Table 1. It is noteworthy that fat and protein contents (4.13 and 3.49%, respectively) were rather high. The contents of other milk components (casein, lactose, FFDM, and urea) corresponded to the average values reported for healthy animals with recorded performance in 2011 (Kvapilík et al., 2012). However, the results also revealed a potential problem in milk quality as the average SCC and TGC were 192 640 and 39 630 in 1 ml of milk, respectively. Especially the high standard deviation and variation coefficient for TGC (48.25 and 121.75, respectively) reflected the occurrence of a certain amount of lower quality milk. In comparison with the average of the CR in 2011 (Kvapilík et al., 2012), we observed below-average SCC, but higher TGC. FP was similar to the nationwide average (-0.52°C) (Kvapilík, 1998; Kvapilík, 2000; Kvapilík et al., 2012).

Table 1. Descriptive statistics of the traits evaluated

Tabulka 1. Základní statistiky sledovaného souboru data

Trait	n	$\bar{x}$	s	min.	max.	V (%)
Fat (%)	78	4.13	0.18	3.4	4.53	4.47
Protein (%)	78	3.49	0.08	3.33	3.69	2.25
Casein (%)	75	2.75	0.08	2.6	3	3.08
Lactose (%)	78	4.82	0.05	4.62	4.91	1.06
FFDM (%)	78	8.89	0.09	8.64	9.13	1
Urea (mmol*l)	76	3.51	0.62	2	4.8	17.76
SCC (x1,000*ml)	78	192.64	57.09	120	370	29.64
TGC (x1,000*ml)	38	39.63	48.25	5	174	121.75
FP (^oC)	78	-0.52	0.01	-0.53	-0.51	-0.52

$\bar{x}$ - arithmetic mean; s - standard deviation; min. - minimum value; max. - maximum value; V (%) - coefficient of variation; FFDM - fat-free dry matter; SCC - somatic cell count; TGC - total germ count; FP - freezing point of milk.

Considerable differences were found between herds and thus between the different milking technologies applied in past years. The average milk production in the parlour ranged from 6,955 kg in 2010 to 7,082 kg in 2011. The average milk production in the AMS ranged from 6,423 in 2008 to 6,830 in 2010. The increase of milk production in the AMS (+ 260 kg in two years) can be explained not only by genetic progress but also by the installation of the AMS in July 2008. Our results generally agreed with the findings of previous studies (Wirtz et al., 2003; Rotz et al., 2003; Davis and Reinemann, 2000) reporting the increase of average milk production after the introduction of milking robots.

Figure 1 shows the proportion of non-standard milk in both milking systems. Markedly higher proportion of non-standard milk was found in the parlour (3.2 %) compared to the AMS (1.04 %). This may be associated with less strict control and subsequently with the later detection of sick and problematic animals in the parlour. The difference may also result from shorter intervals between milkings in the AMS and thus less time necessary for the multiplication of microorganisms causing mastitis (Spahr et al., 1997).

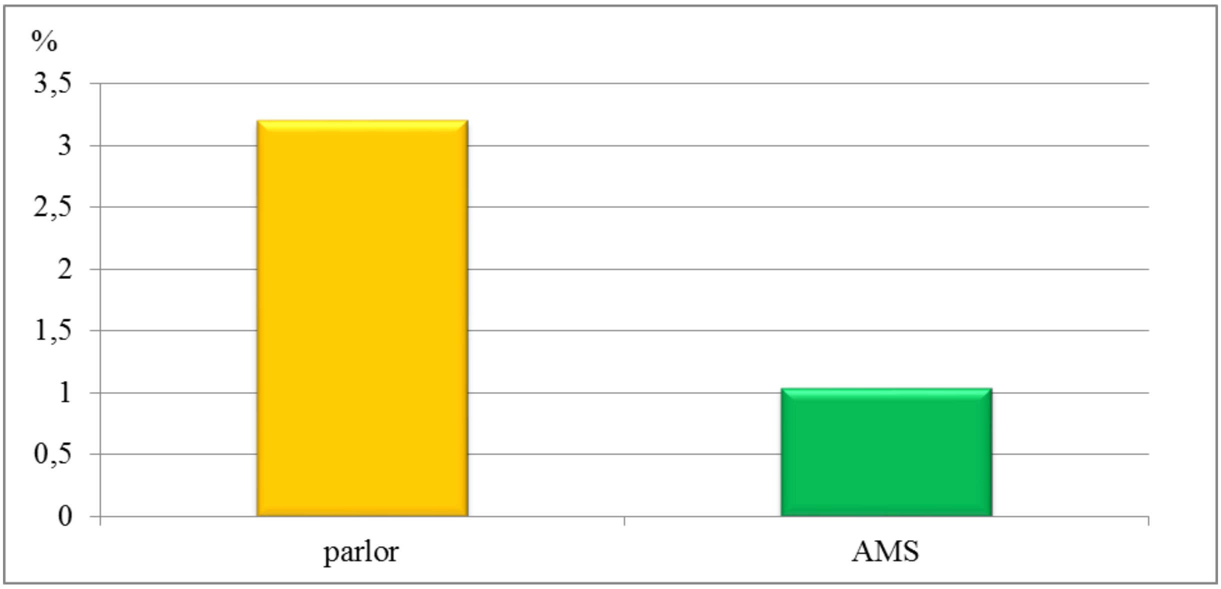

Figure 1. Proportion of non-standard milk in conventional and automatic milking systems in %

Graf 1. Procentický podíl nestandardního mléka v běžném a automatickém systému dojení v %

Pearson correlation coefficients for milk components and quality parameters are given in Table 2. Strong significant correlations (P<0.01) were obtained between the contents of fat and protein (r = 0.581) and casein (r = 0.617). Similarly, a strong and significant correlation (P<0.01) between fat and protein in the milk from the AMS was also observed by Friggins and Rasmussen (2001), as well as in a study by Rajčevič et al. (2003) (r = 0.534). The contents of fat and FFDM were moderately correlated in our study (r = 0.414; P<0.01). Similar values (r = 0.34; P<0.001) were previously determined for Holstein cows (Memiši et al. (2011). The content of fat was correlated negatively with SCC (r = -0.279) and positively with FP (r = 0.282; P<0.05). Low (r = 0.06), positive and significant (P<0.001) correlations were reported previously (Memiši et al., 2011). In contrast to a negative correlation between fat content and SCC in our study, a positive relationship was found between fat content and logarithm of SCC in a study by Friggens and Rasmussen (2001). Strong correlations were calculated between the contents of protein and casein (r = 0.733; P<0.01) and FFDM (r = 0.791; P<0.01), which is in agreement with the relationship between the contents of protein and FFDM found by Memiši et al. (2011). The content of protein was negatively correlated with SCC (r = -0.255; P<0.05). In contrast, positive correlations between protein and logarithm of SCC were reported by Friggens and Rasmussen (2001). No significant correlations between SCC and the contents of fat and protein were, however, observed in Holstein cattle (Yoon et al., 2004). The content of casein was negatively correlated with lactose (r = -0.379; P<0.01) and positively correlated with FFDM (r = 0.433; P<0.01). Similarly to fat and protein, the content of casein was negatively correlated with SCC (r = -0.286; P<0.05). Lactose moderately correlated with FFDM (r = 0.433; P<0.01), negatively correlated with urea (r = -0.297; P<0.01) and FP (r = -0.268; P<0.05). The remaining correlations given in Table 2 were not significant.

Table 2. Correlation coefficients among milk components and quality parameters

Tabulka 2. Korelační koeficienty mezi obsahy složek a ukazateli kvality u mléka

		Protein %	Casein %	Lactose %	FFDM %	Urea (mmol*l)	SCC (x1,000*ml)	TGC (x1,000*ml)	FP (°C)
Fat %	r	0.581	0.617	-0.140	0.414	0.182	-0.279	-0.161	0.282
	P	<.001	<.001	0.22	<.001	0.115	0.013	0.334	0.012
Protein %	r	1	0.733	-0.155	0.791	0.224	-0.255	-0.204	0.119
	P		<.001	0.175	<.001	0.052	0.024	0.219	0.3
Casein %	r		1	-0.379	0.443	0.149	-0.286	-0.172	0.046
	P			<.001	<.001	0.207	0.013	0.302	0.696
Lactose %	r			1	0.435	-0.297	-0.212	0.19	-0.246
	P				<.001	0.009	0.062	0.252	0.03
FFDM %	r				1	-0.01	-0.403	-0.079	-0.03
	P					0.932	<.001	0.639	0.793
Urea (mmol*l)	r					1	0.358	-0.255	0.038
	P						0.002	0.128	0.741
SCC (x1,000*ml)	r						1	-0.2	-0.268
	P							0.228	0.018
TGC (x1,000*ml)	r							1	0.236
	P								0.154

FFDM - fat-free dry matter; SCC - somatic cell count; TGC - total germ count; FP - freezing point of milk.

The effect of the milking technology on milk components and quality was summarised in Table 3 and Table 4. Significant differences were found in almost all the parameters evaluated. The content of fat was higher (+0.16 %; P<0.01) in the AMS compared to the parlour. However, a higher frequency of milking did not affect the content of fat in previous studies (Abeni et al., 2005; Wiking et al., 2006). The content of protein was also higher in the AMS (+0.06 %; P<0.01), which was in agreement with the study by Vorobjovas et al. (2010) who reported higher (P<0.05) contents of fat and protein (+0.09 and +0.08 %, respectively) in cows from the AMS compared to the conventional parlour. However, 0.23 % lower fat content in the AMS was reported in a study by Wirtz et al. (2004). In agreement with the results of the study involving Holstein cattle (Janštová et al., 2011), no effect of the milking technology on the content of lactose was observed in our analysis. The content of FFDM was higher in milk from the AMS (P<0.01).

The milk from the AMS contained more casein (P<0.01), which was in disagreement with Janštová et al. (2011) who did not find different casein contents in Holstein cows milked in the AMS and the conventional parlour. The content of urea was insignificantly higher in the milk from the parlour (+0.09 mmol*l, +2.54 %). In contrast, Vorobjovas et al. (2010) found higher urea content (+21.8 %; P<0.05) in AMS milk. Similarly, shorter intervals between milking events were previously shown to increase the urea content in milk (Nielsen et al., 2005).

A higher SCC was determined in the milk from the conventional herringbone parlour (+58.44 x 14000/ml), perhaps as a result of a higher infection pressure in this environment. It corresponded to the lower SCC values of Holstein cows milked in the AMS (Janštová et al., 2011). Similarly, Berglund et al. (2002) detected significantly higher SCC with increasing lactation days in parlours compared to AMS, which may have been due to more difficult control of SCC and a higher incidence of mastitis in case of milking in conventional parlours. Although not significant, lower SCC were observed in the AMS during our observation and this fact agreed with previous statements. However, increased SCC values were also reported in studies by Kruip et al. (2002), Rasmussen et al. (2002) and Svennersten-Sjaunja and Pettersson (2008). TGC were, however, markedly higher (P<0.05) in the AMS (51.85 x 1,000*ml), which was in agreement with the findings of Klungel et al. (2000).

FP was significantly higher (0.53°C; P<0.01) in milk from the parlour. Opposite results were, however, reported by Rasmussen et al. (2002) in the comparison of conventional and automatic milking systems.

Both stables also differed in the technology of housing (bedded, non-bedded); this, however, generally has no influence on milk composition and quality.

Milk components and quality parameters in different seasons of the year are given in Table 5 and Table 6. The highest fat content (4.24 %) was detected in the period December to February compared to period 1 (P<0.05) and period 2 (P<0.01). The lowest fat content was observed in the period 2 from June to August. Similar differences among seasons and the highest fat content in winter were reported in Holstein cattle (Sitkowska and Piwczyński, 2011). Also Rajčevič et al. (2003) found the highest milk fat contents in winter whereas the lowest in summer. However, Yoon et al. (2004) reported the highest fat content in autumn.

Protein contents were higher (P<0.01) in periods 3 and 4 than in periods 1 and 2. Similar results of protein content changes were observed by Sitkowska and Piwczyński (2011). The highest milk protein contents were measured in winter whereas the lowest in summer in a study by Rajčevič et al. (2003). In contrast, the highest protein was observed in autumn whereas the lowest protein contents were detected in winter and spring in a study byYoon et al. (2004). In addition, unlike in our study, higher protein contents in spring and lower protein contents in autumn were reported by Allore et al. (1997).

The highest lactose content (4.84 %) was found in periods 2 (summer) and 3 (autumn). The lowest (P<0.01) lactose content was detected in winter (4.77 %). In other studies (Sitkowska and Piwczyński, 2011; Rajčevič et al., 2003), however, the highest lactose contents were observed in spring.

The content of FFDM was higher in period 3 (8.94 %) than in periods 1 and 2 (P<0.01). Also Hanuš et al. (2011b) observed the highest FFDM in October and November. The highest content of casein was found in period 4 in our study (2.83 %; P<0.01), which corresponded with the highest and lowest casein contents detected in December (2.74 %) and August (2.30 %) as reported by Lujerdean et al. (2009).

The content of urea determined in period 3 (3.97 mmol*l) was significantly higher (P<0.01) than in periods 1 and 2. Statistical difference (P<0.01) was also detected between periods 2 and 4. Unlike in our study, Yoon et al. (2004) found the highest urea content in winter and spring. However, Hanuš et al. (2011) observed the highest content of urea in October, which was in agreement with our results.

No significant differences in SCC between seasons were determined. The numerically highest value of this milk quality indicator was found in period 3 (211.22 x 1,000*ml). The lowest SCC was, however, observed in spring (184.83 x 1,000*ml). In a study by Rajčevič et al. (2003), the highest and lowest SCC were detected in winter and spring, respectively. In contrast, as reported by Yoon et al. (2004) and Allore et al. (1997), the highest SCC were found in spring months.

TGC were significantly highest (P<0.01 and P<0.05) in period 2 from June to August (+55.46 to +61.7 x 1,000*ml).

No effect of season on FP was found in our study. Hanuš et al. (2011b) observed the lowest and highest FP in spring and autumn, respectively. The difference was, however, only 0.005°C.

Table 3. The effect of milking systems on milk composition and quality

Tabulka 3. Vliv technologie dojení na složení mléka a jeho kvalitu

stable	lable	Fat (%) LSM ± SE	Protein % LSM ± SE	Lactose % LSM ± SE	FFDM % LSM ± SE	Casein % LSM ± SE
1	a	4.05 ± 0.022^{B}	3.46 ± 0.007^{B}	4.82±0.007	8.86 ± 0.010^{B}	2.72 ± 0.009^{B}
2	b	4.21 ± 0.022^{A}	3.52 ± 0.006^{A}	4.83±0.007	8.92 ± 0.010^{A}	2.78 ± 0.009^{A}

FFDM - fat-free dry matter; A, B – statistical significance at P<0.01; a, b - statistical significance at P<0.05.

Table 4. The effect of milking systems on milk composition and quality

Tabulka 4. Vliv technologie dojení na složení mléka a jeho kvalitu

stable	lable	Urea (mmol*l) LSM ± SE	SCC (x1,000*ml) LSM ± SE	TGC (x1,000*ml) LSM ± SE	FP (^{o}C) LSM ± SE
1	a	3.54±0.071	222.30±7.634^{B}	16.51±11.117^{b}	0.53±0.000^{B}
2	b	3.45±0.068	163.86±7.445^{A}	51.85±9.565^{a}	0.52±0.000^{A}

SCC - somatic cell count; TGC - total germ count; FP - freezing point of milk; A, B – statistical significance at P<0.01; a, b - statistical significance at P<0.05.

Table 5. The effect of season on milk composition and quality

Tabulka 5. Vliv efektu období na složení mléka a jeho kvalitu

season	lable	Fat (%) LSM ± SE	Protein % LSM ± SE	Lactose % LSM ± SE	FFDM % LSM ± SE	Casein % LSM ± SE
1	a	4.14±0.031$_{B.d}$	3.46±0.013$_{C.D}$	4.82±0.010^{D}	8.86±0.018$_{C}$	2.73±0.015^{b}$_{.D}$
2	b	3.95±0.029$_{A.C.D}$	3.42±0.013$_{C.D}$	4.84±0.01^{D}	8.85±0.018$_{C}$	2.69±0.013^{a}$_{.D}$
3	c	4.18±0.031$_{B}$	3.52±0.013$_{A.B}$	4.84±0.010^{D}	8.94±0.018$_{A..B}$	2.72±0.014$_{D}$
4	d	4.24±0.028$_{a.B}$	3.54±0.012$_{A.B}$	4.77±0.009^{A}$_{.B.C}$	8.90±0.017	2.83±0.012^{A}$_{.B.C}$

FFDM - fat-free dry matter; A, B, C, D – statistical significance at P<0.01; a,b,c,d - statistical significance at P<0.05.

Table 6. The effect of season on milk composition and quality

Tabulka 6. Vliv efektu období na složení mléka a jeho kvalitu

season	lable	Urea (mmol*l) LSM ± SE	SCC (x1,000*ml) LSM ± SE	TGC (x1,000*ml) LSM ± SE	FP (^{o}C) LSM ± SE
1	a	3.36±0.129^{C}	184.83±11.539	23.5±18.230^{b}	0.52±0.001
2	b	3.13±0.123$^{C.D}$	187.44±10.961	78.96±10.573$^{a.C.D}$	0.52±0.000
3	c	3.97±0.129$^{A.B}$	211.22±11.539	17.26±11.592^{B}	0.52±0.001
4	d	3.63±0.123^{B}	191.23±10.438	21.45±10.573^{B}	0.52±0.000

SCC - somatic cell count; TGC - total germ count; FP - freezing point of milk; A, B, C, D – statistical significance at P<0.01; a,b,c,d - statistical significance at P<0.05.

Conclusions

The objective of the present study was to evaluate the effect of different types of milking (parlour vs. AMS) and the season of the year on milk composition (contents of fat, protein, lactose, FFDM and casein) and quality parameters (urea content, SSC, TGC and FP). Significant correlations of different strength were determined among these traits demonstrating the relationship between nutritional composition and quality parameters of milk. The strongest correlations were calculated between the contents of protein and casein as well as FFDM.

Numerous significant differences were found between the types of milking systems. The milk from the AMS contained significantly higher ($P<0.05 – 0.01$) contents of fat, protein, FFDM, casein, and TGC. In contrast, AMS milk was characterised with lower SCC and FP. Especially lower SCC may be considered an important milk quality improvement. The system of milking did not influence the contents of lactose and urea.

The winter season (period 4) was associated ($P<0.01$) with the highest contents of fat, protein, and casein, and the lowest content of lactose. The highest FFDM, urea, and SCC were observed in autumn (period 3), whereas the highest TGC was found in summer (period 2). Neither statistical differences nor tendencies associated with the season were determined for FP. No statistical differences were, however, detected for SCC as well.

It is concluded that the milking system and season had marked effects on milk components determined within the milk recording scheme.

The results of this study indicated that the use of the AMS had no negative effect on milk components and quality parameters. TGC was the only quality parameter with a higher occurrence in the AMS. A number of other factors different from the system of milking could be related to higher TGC (microclimate, nutrition, housing technology etc.). Therefore, the AMS can be recommended as a suitable alternative to conventional systems of milking, especially in the farming enterprises with less qualified staff available. Acknowledges

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