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EFFECT OF SEASON AND HERD ON RENNET COAGULATION TIME AND OTHER PARAMETERS OF MILK TECHNOLOGICAL QUALITY IN HOLSTEIN DAIRY COWS

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Abstract

CHLÁDEK, G., ČEJNA, V., FALTA, D., MÁCHAL, L.: *Effect of season and herd on rennet coagulation time and other parameters of milk technological quality in Holstein dairy cows.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 5, pp. 113–118

In five herds of purebred Holstein dairy cows, altogether 220 bulk milk samples were collected with the following average parameters: rennet coagulation time (RCT) 265.2 sec., titratable acidity 6.40 °SH, active acidity 6.72 pH, specific density 1.0281 $kg.l^{-1}$, fat content 3.81 $g.100g^{-1}$, protein content 3.28 $g.100g^{-1}$, lactose content 4.72 $g.100g^{-1}$, and content of solids non-fat content 8.89 $g.100g^{-1}$; average values of milk batch volume per herd and diurnal air temperature were 6,072 kg and 8.02 °C, respectively. It was found out that the variable "season" (spring, summer, autumn or winter) significantly influenced nearly all parameters under study (the only exceptions were values of titratable acidity and milk batch volume). As compared with all other seasons, the significantly shortest RCT was recorded in summer. Further it was also found out that the variable "herd" influenced all parameters with the exception of average diurnal air temperature. Regardless to differences existing among individual herds, the shortest average RCT was recorded always in summer.

dairy cow, milk, composition, coagulation time, season, Holstein breed, herd

According to Janů *et al.* (2007) and Hanuš *et al.* (2010), the technological quality of milk is influenced not only by fat, protein, lactose and solids non-fat but also by such parameters as active acidity and titratable acidity. Besides, rennet coagulation time (RCT), firmness of rennet curd, and volume of whey separated out during the process of enzymatic coagulation of milk are also very important (Hanuš *et al.*, 2007). RCT of milk influences significantly the process of cheesemaking and also cheese yield, and its quality (Johnson *et al.*, 2001). It is also an important parameter when evaluating milk suitability for processing and cheesemaking (Cassandro *et al.*, 2008). Ikonen and Ruottinen (1999), as well, mentioned that their observations indicated that an improvement in coagulation properties of herd bulk milk could improve the efficiency of cheesemaking. However, also those authors who did not primarily study problems of technological quality of milk concluded that the coagulation properties of milk (i.e. its rennetability) should be involved among effects analysed in experiments with dairy cows (Marchesini *et al.*, 2009; Masoero *et al.*, 2009).

As mentioned by Daviau *et al.* (2000), it is well known that reducing the milk active acidity from 6.7 to 5.8 pH resulted in a faster rennet coagulation and that also reducing concentrations of casein led to a shortening of the coagulation time. Jõudu *et al.* (2008) concluded that an increase in milk protein, casein, casein fractions, and the casein number decreased the rennet coagulation time of milk. Nájera *et al.* (2003) observed in their study that the rennet coagulation time decreased in dependence on increasing coagulation temperature; on the other hand, however, an increase in pH resulted in their experiments in a prolongation of rennet coagulation time. The existence of phenotypic and genotypic correlations between milk coagulation time and protein content (0.02 and 0.22, respectively) was mentioned by Ikonen *et al.* (2004); according to Comin *et al.* (2005) the values of these correlations were –0.041 and 0.128, respectively.

As far as the effect of breed on composition and technological quality of milk is concerned, it can be also considered as a relatively important factor. A lower technological quality of milk produced by Holstein dairy cows was mentioned by several authors who compared them with other breeds (Malacarne *et al.*, 2005; De Marchi *et al.*, 2007; Hanuš *et al.*, 2010). In spite of this negative feature, the Holstein breed is widely used and preferred by many cattle breeders, above all because of its high milk performance. However, it should be also mentioned in this context that differences in milk technological quality can be found out even within one single breed. Matějíček *et al.* (2008) studied the effect of kappa-casein (CSN3) and beta-lactoglobulin (LGB) genotypes on milk quality and coagulation properties in the Czech Fleckvieh breed. The above authors found out that in this breed the maximum value of RCT (135 s.) occurred in the genotypic variant BBBB while the shortest RCT (90 s.) existed in the variant BBAA. The content of milk protein, however, showed an opposite trend in these genotypes.

Marked environmental effects on individual parameters of milk technological quality also cannot be neglected. These effects are usually involved into such models as effects of herd, year or season. So, for example De Marci *et al.* (2007) mentioned that in their experiments, milk produced by dairy cows of Holstein-Friesian breed showed the worst coagulation properties (including RCT) among all other breeds under study. In September and October, however, values of RCT were slightly better. Besides an important effect of breed, these authors mentioned also a highly significant within-breed effect of herd. In the Czech Republic, Hanuš *et al.* (2011) observed that herd, year, and season showed a significant effect on milk composition and its technological properties (including RCT) of milk produced by dairy cows of the Czech Fleckvieh breed.

The aim of this study was to analyse effects of season and herd on the rennet coagulation time and other parameters of technological quality of milk produced by dairy cows of Holstein breed.

MATERIAL AND METHODS

Within one year, altogether 220 bulk milk samples were collected in five herds (A, B, C, D, E) in the course of all four seasons: spring, summer, autumn and winter. All herds under study consisted only of purebred Holstein dairy cows. These bulk samples were a mixture of morning and evening milk. Milk samples were collected in all herds simultaneously (i.e. within one day) in one-week intervals for a period of 44 weeks and their analysis was performed immediately after the delivery of produced milk into the dairy factory. The following parameters of milk technological quality were analysed:

Rennet coagulation time (RCT), which was measured by means of a turbidimetric sensor of milk coagulation process (Skýpala and Chládek, 2005).

Active acidity (AA) was measured with the pH-meter WTW pH 197.

Titratable acidity (TA) was measured by milk titration (100 ml) using alkaline solution up to a light pink colour of the mixture (in ml of the 0.25 $mol.l^{-1}$ $naOH.100ml^{-1}$).

Diurnal air temperature (T) was calculated as an arithmetic mean of temperatures measured at 7:00, 14:00 and 21:00 (twice) hours on the day preceding the day of milk analysis.

Specific density (SD) was measured by lactometer.

Milk composition involved fat content (**F**; $g.100g^{-1}$), crude protein (**P**; $g.100g^{-1}$), lactose (**L** – lactose monohydrate; $g.100g^{-1}$) and solids non-fat (**SNF**; $g.100g^{-1}$); these values were estimated using the NIR analyser MilkoScan S50.

Milk batch volume (Q) was estimated in milking parlours before bulk milk transportation from dairy farms.

Effects of season and herd were analysed using the GLM method of the programme STATISTICA (version 9.0) in which season, herd and week were used as constant effects.

RESULTS AND DISCUSSION

Effects of individual seasons on milk parameters under study are presented in Tab. I. As one can see, numbers of samples evaluated within the framework of an individual season ranged from 45 to 65 in summer and in the spring, respectively. In individual seasons, the following average diurnal temperatures were ascertained: 8.30 °C in the spring, 17.39 °C in summer, 6.48 °C in the autumn and 1.10 °C in winter. Although the spring temperatures were similar to those measured in the autumn, the differences among all seasonal temperatures were significant. Excepting titratable acidity and milk batch volume, the effect of season on all parameters of milk technological quality was significant. As compared with spring, autumn and winter, the significantly shortest rennet coagulation time was observed in summer (winter values of RTC were the longest). Contents of fat, protein, and solids non-fat were the lowest in summer while that of specific density was the highest. In the autumn, values of active acidity, specific density and lactose content were the lowest while those of fat content and protein content were the highest. In winter, values of active acidity and solids non-fat content were the highest.

Values of average diurnal temperatures calculated in individual seasons corresponded in essence to those mentioned in a study by Walterová *et al.*

(2009) and documented also the absence of extreme climatic changes in the course of this experiment. The value of summer average diurnal temperature indicated that the limit of heat stress could be overpassed on some days in this season (Kadzere *et al.*, 2002; Brouček *et al.*, 2006; Hanuš *et al.*, 2008). This fact could also be one of causes of a significant difference in values recorded in this season of the year (above all of RCT, fat, protein, solids non-fat, and/or specific density). When comparing our results with those published by Daviau *et al.* (2000), the observed shorter RCT was not associated with a decrease in active acidity; however, this shorter RCT was associated with a decrease in the content of protein, which is usually associated also with a decrease in the content of casein. The fact that our lower values of RCT were associated with a reduced content of protein does not correspond with data published by Jõudu *et al.* (2008) who presented an opposite result. This could be partly explained on the base of high summer temperatures recorded in our study; this finding also corresponded with results published by Nájera *et al.* (2003). Another cause of this might be a not too close relationship existing between RCT and protein content, which indicated by values of genotypic and phenotypic correlations published by Ikonen *et al.* (2004) and Comin *et al.* (2005).

The effect of herd on milk parameters under study is illustrated in Tab. II. These data indicate a marked effect of herd on all parameters of milk technological quality; non-significant is only the effect of air temperature. The maximum differences among individual herds were as follows: rennet coagulation time (RCT) 70.3 sec, titratable acidity 0.15 °SH, active acidity 0.06 pH, specific density 0.0004 kg.l^{-1}, fat content 0.32 g.100g^{-1}, protein content 0.11 g.100g^{-1}, lactose content 0.10 g.100g^{-1}, solids non-fat content 0.07 g.100g^{-1}, and milk batch volume 10,370 kg. This table and Fig. 1. explicitly indicate that the shortest average rennet coagulation time (RCT) was always recorded in summer (regardless to differences among individual herds).

Identical average diurnal temperatures recorded in individual herds under study document that the sampling procedure was fully correct. Volumes

I: *Effect of season on milk parameters under study*

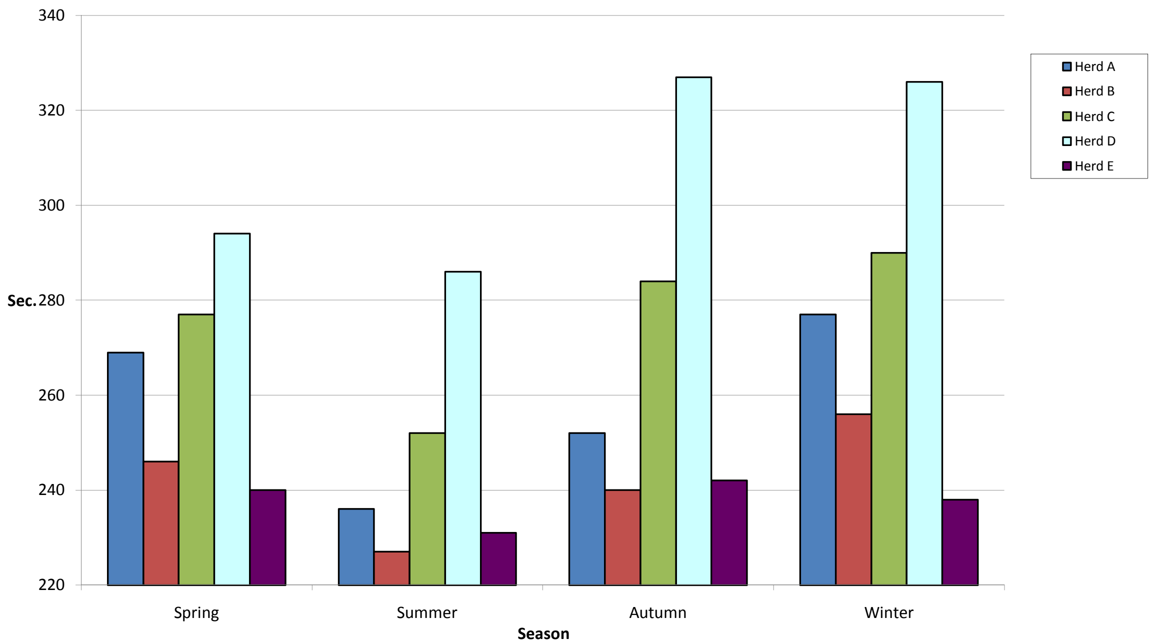
Milk parameter	Units	$\bar{x}$	Season			
			Spring	Summer	Autumn	Winter
Number of bulk milk samples	n	220	65	45	60	50
Air temperature	°C	8.02	8.30 ^{b}	17.39 ^{a}	6.48 ^{b}	1.10 ^{c}
Rennet coagulation time	sec.	265.2	265.2 ^{b}	246.3 ^{a}	269.0 ^{b}	277.7 ^{b}
Titratable acidity	°SH	6.40	6.41 ^{a}	6.40 ^{a}	6.40 ^{a}	6.40 ^{a}
Active acidity	pH	6.72	6.73 ^{a}	6.71 ^{b}	6.70 ^{b}	6.74 ^{a}
Specific density	kg.L^{-1}	1.0281	1.0281 ^{bc}	1.0282 ^{c}	1.0280 ^{c}	1.0280 ^{ab}
Fat content	g.100g^{-1}	3.81	3.78 ^{ab}	3.69 ^{c}	3.89 ^{c}	3.87 ^{bc}
Protein content	g.100g^{-1}	3.28	3.21 ^{a}	3.18 ^{a}	3.38 ^{b}	3.35 ^{b}
Lactose content	g.100g^{-1}	4.72	4.75 ^{c}	4.74 ^{bc}	4.68 ^{a}	4.70 ^{ab}
Solids non-fat content	g.100g^{-1}	8.89	8.85 ^{b}	8.78 ^{a}	8.94 ^{c}	8.97 ^{c}
Milk batch volume	kg	6,072	6,088 ^{a}	6,194 ^{a}	5,987 ^{a}	6,043 ^{a}

a-e within the same parameter: P ≤ 0.05

II: *Effect of herd on milk parameters under study*

Milk parameter	Units	$\bar{x}$	Herd				
			A	B	C	D	E
Number of bulk milk samples	n	220	44	44	44	44	44
Air temperature	°C	8.02	8.02 ^{a}	8.02 ^{a}	8.02 ^{a}	8.02 ^{a}	8.02 ^{a}
Rennet coagulation time	sec.	265.2	259.5 ^{b}	242.7 ^{a}	276.9 ^{c}	308.6 ^{d}	238.3 ^{a}
Titratable acidity	°SH	6.40	6.36 ^{a}	6.39 ^{b}	6.39 ^{b}	6.37 ^{b}	6.51 ^{c}
Active acidity	pH	6.72	6.74 ^{b}	6.72 ^{a}	6.71 ^{a}	6.75 ^{b}	6.69 ^{a}
Specific density	kg.L^{-1}	1.0281	1.0281 ^{a}	1.0281 ^{a}	1.0282 ^{a}	1.0278 ^{b}	1.0281 ^{a}
Fat content	g.100g^{-1}	3.81	3.80 ^{a}	3.75 ^{a}	3.72 ^{a}	4.04 ^{b}	3.76 ^{a}
Protein content	g.100g^{-1}	3.28	3.27 ^{ab}	3.22 ^{a}	3.33 ^{c}	3.29 ^{bc}	3.31 ^{bc}
Lactose content	g.100g^{-1}	4.72	4.74 ^{c}	4.77 ^{c}	4.67 ^{a}	4.68 ^{ab}	4.72 ^{bc}
Solids non-fat content	g.100g^{-1}	8.89	8.90 ^{ab}	8.87 ^{ab}	8.89 ^{ab}	8.86 ^{a}	8.93 ^{b}
Milk batch volume	kg	6,072	11,874 ^{a}	9,697 ^{b}	3,097 ^{c}	1,504 ^{d}	4,186 ^{e}

a-e within the same parameter: P ≤ 0.05



1: *Course of RCT in herds under study in individual seasons*

of milk delivered to dairies from individual herds indicated average numbers of dairy cows on individual dairy farms (i.e. from 100 to 500 animals). As mentioned by Matějíček *et al.* (2008), differences in technological quality and milk composition parameters had to be surely determined by their genotype because all dairy cows were of the same breed. However, we must not forget that individual parameters of milk technological quality produced in individual herds under study were markedly influenced by the environment, which also could deepen existing differences.

It can be therefore concluded that differences in RTC, as observed in our study (i.e. 22.7 %), were nearly the same as those recorded by Hanuš *et. al.* (2010) under different conditions and in different breeds (34.0 %). The existence of significant differences among individual breeds support the requirement that the parameter „breed“ should be taken into account as one of factors influencing results of experiments concerning technological quality of milk. A significant effect of herd on parameters of technological quality of milk observed in our study corresponds not only with results published by De Marci *et al.* (2007) but also by Hanuš *et al.* (2011) who recorded them in a different breed of cattle.

SUMMARY

In five herds of purebred Holstein dairy cows (A, B, C, D and E), altogether 220 bulk milk samples were collected in the course of four seasons spring, summer, autumn, and winter. Average values of technological milk quality were as follows: rennet coagulation time (RCT) 265.2 sec., titratable acidity (TA) 6.40 °SH, active acidity (AA) 6.72 pH, specific density (SD) 1.0281 kg.l^{-1}, fat content (F) 3.81 g.100g^{-1}, protein content (P) 3.28 g.100g^{-1}, lactose content (L) 4.72 g.100g^{-1} and solids non-fat content (SNF) 8.89 g.100g^{-1}; average values of milk batch volume per herd (Q) and diurnal air temperature (T) were 6,072 kg and 8.02 °C, respectively. The effect of season on nearly all parameters under study was significant (the only exceptions were TA and Q). When comparing all four seasons, the significantly shortest RCT was recorded in summer while in winter it was the longest. In summer, values of F, P and SNF were the lowest while that of SD was the highest. In the autumn, the lowest values of AA, SD and L were recorded while those of F and P were the highest. In winter, values of AA and SNF were the highest of all seasons. The effect of herd on nearly all parameters under study was significant (the only exception was T). Maximum differences among individual herds were as follows: RCT 70.3 sec, TA 0.15 °SH, AA 0.06 pH, SD 0.0004 kg.l^{-1}, F 0.32 g.100g^{-1}, P 0.11 g.100g^{-1}, L 0.10 g.100g^{-1}, SNF 0.07 g.100g^{-1}, and Q 10,370 kg. As far as individual herds were concerned, the shortest average value of RCT was always observed in summer.

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