



FACTORS AFFECTING RAW MILK QUALITY OF DAIRY COWS UNDER PRACTICAL CONDITIONS

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ABSTRACT

Under the practical conditions, it is important to evaluate the factors affecting milk performance. Data from test day yield and milk components should be useful for such evaluation. The aim of the experiment was to study the effect of season, udder health (by somatic cell counts SCC), parity, stage of lactation on milk production, milk components, and SCC under the practical conditions. Also, the frequency of incidence of high SCC during the season was observed. The experiment was realized on one dairy farm in dairy practice. The experiment lasted from December 2015 to October 2017. We examined 481 Holstein dairy cows (6910 milk samples). Milk samples were collected once per month – performed by recording test day. Only cows with 9 – 11 test days were evaluated. The effect of season, parity, stage of lactation, and SCC influenced most of the studied traits. The milk yield was highest at 2nd lactation. In the following lactations, the milk yields were decreasing. The SCC significantly increased with advanced parity. The elevated SCC was found in the beginning and in the final part of lactation. SCC as a factor significantly reduced milk yield, lactose content but increased fat and protein content. In conclusion, under practical conditions, the management should use the data from test days and analyze them for a better understanding of the performance efficiency at the farm level and for implementing more sophisticated decision making in farming.

Keywords: dairy cows; data; milk; performance

INTRODUCTION

Raw milk production and its quality at the farm level depends on many factors of external and internal conditions. Most often there are described external factors especially heat stress, season, humidity (Lambertz, Sanker and Gauly, 2014), and internal factors like parity, stage of lactation, udder health, metabolic status (Tančín, Ipema and Hogewerf, 2007; Tančín et al., 2007; Penev et al., 2014). Most of the articles published the results under experimental conditions, but conditions at the farm level are often different due to management practices, even if the breeding conditions are the same. Thus, the effect of above-mentioned factors under practical conditions could be an important source of information for the optimal management of each dairy farm.

One of the most important information coming from the dairy practice is data obtained from milk recording test days (milk yield, milk components, somatic cell count – SCC) performed in a monthly period. After processing, these data could be used for the management of dairy cows. One of the most important information coming from test day is data indicating udder health through SCC (Tančín, 2013). SCC is a gold standard in diagnosing of any forms of mastitis of the udder (Pyörälä, 2003;

Bobbo et al., 2017) and it is also negatively related to milk yield and its components (Barkema et al., 1999, Kull et al., 2019), and to technological quality of milk (Santos, Ma and Barbano, 2003; Leitner et al., 2004, Franzoi et al., 2020). SCC data are used in the selection of dairy cows (Strapakova, Candrak and Strapak, 2016). Thus, the economic impact of mastitis should be seriously considered (Petrovski, Trajcev and Buneski, 2006) at the farm level. SCC in raw milk is also affected by other internal and external factors like stage of lactation, parity (Tančín, Ipema and Hogewerf, 2007; Tančín et al., 2007), frequency of milking (Hogeveen et al., 2001). However, from the health point of udder, these factors did not increase SCC dramatically as the mastitis do.

Milk production, its components, and udder health (represented by SCC) are data available for dairy farms through regular milk recording test day. However, at the farm level, these data are not processed correctly or even not used. Moreover, critical scientific evaluation of these data could be also important. The aim of the experiment was to study the effect of season, parity, stage of lactation on milk production, its components, and SCC under the practical conditions.

Scientific hypothesis

The season, udder health, parity, stage of lactation significantly influence milk yield, milk components and SCC. SCC reduced milk yield and changed milk components.

MATERIAL AND METHODOLOGY

The experiment was realized in one dairy farm in dairy practice. There were black Holstein cows on the farm with average year milk production 10,500 kg. The experiment lasted from December 2015 till October 2017, during which we examined 481 dairy cows. In total, 739 records of cows were evaluated, as in some cows also 2nd, 3rd, and higher lactations were included. Thus, 36% of evaluated cows were on their first lactation, 26% on their second, 18% on third, 12% on fourth, and 8% on the fifth lactation.

The dairy cows were housed in a free housing system with cubicles. Animals were milked three times a day in 2x10 parallel milking parlour. The parlour was equipped with automatic devices for cluster removal. The milking routine included also udder cleaning with towel and fore-stripping. The cows were fed by a total mix ration two times a day.

Milk samples were collected once per month – on the official recording test day. Only cows with 9 – 11 test days were involved in the statistical examination of data. Some samples were excluded from the evaluation due to insufficient milk collection which was insufficient for analysis of all milk parameters. Thus, in total 6910 samples from the experimental period were included and used for statistical evaluation. The basic milk components (fat, protein, lactose) were determined by MilkoScan FT120 (Foss, Hillerød, Denmark) and somatic cells count were determined using a Fossomatic 90 (Foss Electric, Hillerød, Denmark) after heat samples at 40 °C for 15 min.

Animals on the basis of SCC were divided into four groups: low (SCC <3x10⁵ cells.mL⁻¹), middle (SCC between 3x10⁵ and 6x10⁵ cells.mL⁻¹), high (SCC between 6x10⁵ and 10⁶ cells.mL⁻¹) and the highest (SCC >10⁶ cells.mL⁻¹). We also created 5 groups of animals according to their parity numbers (first, second, third, fourth, fifth, and subsequent lactation). The stage of lactation was divided into four groups (into intervals of approximately 90 days) – in the first group the cows were on their 52.91 ±21.76 days of lactation, in the second one on 135.01 ±25.96 days, in the third on 224.58 ±26.22 days and the fourth on 296.85 ±16.72 days of lactation. In terms of the season we considered four groups – winter (December, January, February), spring (March, April, June), Summer (June, July, August), Autumn (September, October, November).

Statistical analysis

Obtained data were processed by Microsoft Excel and statistically evaluated by SAS/8.2 (2002). The model was tested by using Fisher's F-test. Differences between the levels of the effects were tested by Scheffe multiple range test for studied traits. Data are presented as LSmeans ± standard error for evaluation of somatic cells the following model was used:

$$y = X\beta + Zu + e$$

Where:

y – was the measurements for somatic cell counts; β – the fixed effects of parity, stage of lactation, season, SCC group; u – random effect of cow, $u \sim N(0, I \delta_2c)$; e – random error, assuming $e \sim N(0, I \delta_2e)$; X, Z – incidence matrices for fixed effects and random cow effect, resp.

RESULTS AND DISCUSSION

There is the basic statistics of evaluated data in Table 1. The mean of the daily milk production corresponded to the data obtained from the well managed farm (Tančín et al., 2006). In this herd, the mean of SCC was above the limit for SCC in bulk milk tank (EU regulation 853/2004). On average 76.66% of samples were in the low SCC group and 10.25% of samples were in the highest SCC group of the studied herd. Some seasonal effect was also observed, were in the low SCC group the lowest percentage (70.55%) of samples were in summer 2015 and the highest percentage of samples (81.65 %) were in autumn 2016 (Figure 1).

The effect of season, parity, stage of lactation, and SCC groups influenced most of the studied traits (Table 2). The effect of SCC on fat/protein ratio and parity on protein in milk was not found. The highest LSmeans of milk yield was detected in summer 2015 (32.79 ±0.45 kg) and the lowest in autumn 2016 (27.04 ±0.38 kg, $p < 0.05$). Throughout the study, there were higher milk yields in Spring and Summer with the following decrease in Autumn periods. The highest fat content was found in Winter 2015/2016 (4.41 ±0.03%) and the lowest in Summer 2017 (3.76 ±0.04%, $p < 0.05$). The concentration of protein was the highest in Winter 2016/2017 (3.39 ±0.02%) and the lowest in Summer 2015 (3.11 ±0.02%, $p < 0.05$). The range of lactose LSmeans were from 4.66 ±0.01 % (Autumn 2015) to 4.78 ±0.01% (Winter 2014/15 and Spring 2015). The SCC was lowest in Spring and Summer 2016 (5.12 ±0.03 logPSB.mL⁻¹) and the highest in Spring and Summer 2015 and Summer and Autumn 2017 (5.24 ±0.03 logPSB.mL⁻¹). The significant differences among seasons in SCC were only between summer 2015 and summer 2016 ($p < 0.05$). Though the seasons of the year significantly influenced studied trials in dairy cows, in general, the same seasons did not have a similar effect on studied traits (Table 3). The significant differences of LSMeans at fixed factor „Season“ can be found in Table 4.

Most frequently in the science, the season is discussed in relation to SCC. Summer period seems to be a risk factor for udder health in the fact that environmental pathogens caused a higher incidence of mastitis during the summer period (Smith, Todhunter and Schoenberger, 1985; Penev et al., 2014) as a possible consequence of suitable living conditions for bacteria (Mallet et al., 2012). This was also confirmed in our previous work in dairy practice (Tančín 2013), where there was a significant increase of SCC during the period of May, June, and July as compared with winter months of the year. But at present work, the summer was not confirmed as the most critical season (Table 3). Another work showed more critical period on mastitis occurrence in the winter season (Olde Riekerink, Barkema and Stryhn, 2007). Under the conditions of healthy mammary glands, the season was pointed out to have no significant influence on SCC (Malinowski, 2001).

In our study, we had summers with the highest, but also the lowest SCC, so other important factors like management and effective mastitis control program might be more important. The climatic, microclimatic conditions and feeding vary from year to year that could diminish or extend the difference among seasons. The stage of lactation is an important factor affecting milk performance. Milk yield and protein content significantly decreased from the first to the fourth stage of lactation (Table 5). Fat content was the highest in the fourth stage and lactose was reduced during the last stages of lactation (third and fourth stage). The SCC significantly changed from the stage to stage of lactation with higher SCC at the first stage, with a reduction in second and again with an increase in the third and the fourth stage of lactation (Table 5). The changes of SCC during lactation showed the most critical period for SCC in the beginning and in the end of lactation. These changes are generally known (Tančín, 2013) and again were confirmed at practical conditions. A

significant effect of the stage of lactation in dairy cows was also documented by Laevens et al. (1997) and Sebastino, Uribe and Gonzalez (2020). From the management point of view, the period early postpartum and before drying are critical for udder health. Therefore, more attention should be focused on the care of cows during both mentioned periods of lactation.

The milk yield and its components and SCC in relation to the parity are shown in Table 5. Milk yield was the highest at second lactation with decreasing in the following lactations. The SCC significantly increased with advanced numbers of lactation. Especially the group of cows on their fifth and subsequent lactations had $5.59 \pm 0.05 \log_x \text{mL}^{-1}$, compared to primiparous cows with $4.88 \pm 0.03 \log_x \text{mL}^{-1}$. There were no significant differences between the first two groups of parities indicating a relatively low increase of health problems during the first two lactations. In our earlier study (Tančín, Ipema and Hogewerf, 2007) the multiparous cows had only numerically higher SCC as

Table 1 The basic statistics of evaluated data.

Parameter	N	Minimum	Maximum	Mean	Std Error
Yield, kg	6910	2.50	56.80	33.07	0.11
Fat, (F) %	6910	1.18	9.90	3.88	0.01
Protein, (P) %	6910	2.02	9.33	3.16	0.004
Lactose, %	6910	2.62	5.42	4.83	0.002
SCC, $\times 10^3 \text{mL}^{-1}$	6910	4.00	29603	503.59	18.98
logSCC	6910	3.30	7.47	5.02	0.01
Ration F/P	6910	0.32	3.05	1.23	0.002

Table 2 Results of variance analysis for milk yield and milk component traits (statistical significance of the Sheffe-test).

Factors/Traits	Yield (kg)	Fat (%)	Protein (%)	Lactose (%)	Ratio F/P	logSCC
Season	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Lactation stage	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Parity	<.0001	<.0001	0.5079	<.0001	<.0001	<.0001
SCC group	<.0001	<.0001	<.0001	<.0001	0.8163	

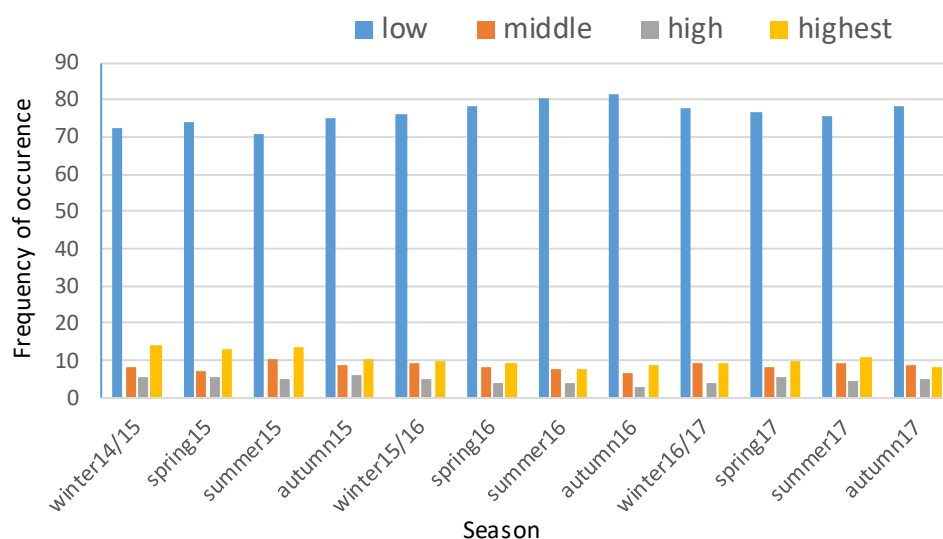


Figure 1 The effect of season and frequency of occurrence (%) of samples in SCC group (from 2014 to 2016 on occurrence of samples in different SCC group. Low (SCC $< 3 \times 10^5 \text{cells.mL}^{-1}$), middle (SCC between 3×10^5 and $6 \times 10^5 \text{cells.mL}^{-1}$), high (SCC between 6×10^5 and $10^6 \text{cells.mL}^{-1}$) and highest (SCC $> 10^6 \text{cells.mL}^{-1}$).

Table 3 Least squares means for milk yield and its composition traits according season.

N	Factor	Parameters											
		Yield (kg)		Fat (%)		Protein (%)		Lactose (%)		Lactose (%)		logSCC	
		LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error
1	Winter 2014/15	33.48	0.55	3.92	0.05	3.36	0.02	4.78	0.01	1.18	0.01	5.18	0.04
2	Spring 2015	32.63	0.49	3.92	0.04	3.24	0.02	4.78	0.01	1.21	0.01	5.24	0.04
3	Summer 2015	32.79	0.45	3.95	0.04	3.11	0.02	4.70	0.01	1.28	0.01	5.24	0.03
4	Autumn 2015	29.11	0.43	4.07	0.04	3.29	0.02	4.66	0.01	1.24	0.01	5.22	0.03
5	Winter 2015/16	30.02	0.41	4.30	0.04	3.37	0.02	4.70	0.01	1.28	0.01	5.17	0.03
6	Spring 2016	30.43	0.39	4.00	0.04	3.29	0.02	4.72	0.01	1.22	0.01	5.12	0.03
7	Summer 2016	29.49	0.39	4.00	0.04	3.20	0.02	4.72	0.01	1.26	0.01	5.12	0.03
8	Autumn 2016	27.04	0.38	4.08	0.04	3.36	0.02	4.70	0.01	1.22	0.01	5.17	0.03
9	Winter 2016/17	27.32	0.37	4.41	0.03	3.39	0.02	4.72	0.01	1.31	0.01	5.17	0.03
10	Spring 2017	30.41	0.37	3.98	0.03	3.24	0.02	4.73	0.01	1.23	0.01	5.22	0.03
11	Summer 2017	31.54	0.40	3.76	0.04	3.17	0.02	4.77	0.01	1.19	0.01	5.24	0.03
12	Autumn 2017	27.56	0.53	4.10	0.05	3.24	0.02	4.74	0.01	1.27	0.02	5.24	0.04

Table 4 Significant differences of LSMeans at fixed factor „Season“ (explanation in table 3 „N“).

Yield	Fat	Protein	Lactose	Ratio F/P	logSCC
1: 4; 5; 6; 7; 8; 9; 10; 12;	1: 5; 9; 2: 5; 9;	1: 2; 3; 7; 10; 11; 2: 3; 5; 8; 9;	1: 3; 4; 5; 6; 7; 8; 9; 10	1: 3; 4; 5; 6; 7; 9; 3: 7; 10; 12;	
2: 4; 5; 6; 7; 8; 9; 10; 12;	3: 5; 9; 4: 5; 9; 11	3: 4; 2; 6; 7; 8; 9; 10; 12;	2: 3; 4; 5; 6; 7; 8; 9; 10;	2: 3; 5; 9; 3: 6; 8; 11;	
3: 4; 5; 6; 7; 8; 9; 10; 12;	5: 6; 7; 8; 10; 11; 6: 9; 11;	4: 5; 7; 9; 11; 5: 6; 7; 10; 11; 12;	3: 4; 11; 4: 5; 6; 7; 8; 9; 10; 11; 12;	4: 9; 5: 6; 8; 10; 11; 6: 9;	
4: 8; 9; 11	7: 9; 11;	6: 7; 9; 11;	11: 5; 6; 7; 8; 9; 10;	7: 9; 11; 8: 10;	
5: 8; 9;	8: 9; 11;	7: 8; 9;	10;	9: 10; 11;	
6: 8; 9; 12;	9: 10; 11; 12;	8: 9; 11; 12;		11: 12;	
7: 8; 9; 11;	10: 11;	9: 10; 11; 12;			
8: 10; 11;	11: 12				
9: 10; 11;					
10: 12;					
11: 12;					

compared with primiparous cows and this difference is in agreement with other findings (Laevens et al., 1997).

Recently Sebastino, Uribe and Gonzalez (2020) showed a significant increase of SCC with parity.

SCC as an internal factor significantly reduced milk yield and lactose content on one side and increased the content of fat and protein (Table 5). A similar effect of SCC on milk yield we demonstrated earlier (Tančin, Ipema and Hogewerf, 2007). However, in another study, the lowest fat, SNF, protein, and lactose were determined in milk with SCC >500x10³ cells.mL⁻¹ (Kull et al., 2019). It was further observed that fat % expressed a negative phenotypic correlation with SCC (Wagay et al., 2018).

Recently, Concalves et al. (2018) also demonstrated the daily milk losses caused by increased SCC. Bezman et al. (2015) found out a decrease in milk yield and lactose with increased SCC caused by the presence of mastitis pathogens. In milk with high SCC, the last-mentioned authors also demonstrated an increase or decrease of the protein in milk and a decrease or no changes of fat. These changes were influenced by the presence of different pathogens. In our study, we did not have any information about the presence of pathogens.

Table 5 Least squares means milk yield and its components according estimated factors.

Factor	Traits											
	Yield (kg)		Fat (%)		Protein (%)		Lactose (%)		Ration F/P		logSCC	
	LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error	LSM	Std. error
Stadium1	34.41 ^a	0.38	4.08 ^a	0.03	3.14 ^a	0.02	4.76 ^a	0.01	1.31 ^a	0.01	5.17 ^a	0.02
Stadium2	33.80 ^a	0.37	3.82 ^b	0.03	3.15 ^a	0.02	4.79 ^a	0.01	1.21 ^b	0.01	5.10 ^b	0.02
Stadium3	28.64 ^b	0.37	4.01 ^a	0.03	3.34 ^b	0.02	4.71 ^b	0.01	1.20 ^b	0.01	5.18 ^a	0.03
Stadium4	23.75 ^c	0.44	4.24 ^c	0.04	3.46 ^c	0.02	4.65 ^c	0.01	1.22 ^b	0.01	5.29 ^c	0.03
1 st Lactation	28.85 ^a	0.44	4.12 ^a	0.03	3.25 ^a	0.02	4.76 ^a	0.01	1.27 ^a	0.01	4.88 ^a	0.03
2 nd Lactation	31.53 ^b	0.39	3.94 ^b	0.04	3.28 ^a	0.02	4.76 ^a	0.01	1.20 ^b	0.01	4.93 ^a	0.02
3 rd Lactation	31.27 ^{bc}	0.44	3.99 ^{ab}	0.04	3.29 ^a	0.02	4.73 ^a	0.01	1.22 ^{bc}	0.01	5.17 ^b	0.03
4 nd Lactation	30.20 ^{ab}	0.51	4.13 ^{ac}	0.04	3.28 ^a	0.02	4.70 ^b	0.01	1.27 ^{ac}	0.01	5.36 ^c	0.04
Lactation ≥5	28.90 ^a	0.65	4.00 ^{abc}	0.04	3.26 ^a	0.03	4.67 ^b	0.01	1.23 ^{abc}	0.02	5.59 ^d	0.05
SCC low	33.14 ^a	0.31	3.90 ^a	0.04	3.16 ^a	0.01	4.84 ^a	0.01	1.24	0.01		
SCC middle	29.79 ^b	0.40	4.03 ^b	0.04	3.28 ^b	0.02	4.75 ^b	0.01	1.23	0.01		
SCC high	29.66 ^b	0.47	4.10 ^b	0.05	3.31 ^{cb}	0.02	4.71 ^c	0.01	1.24	0.01		
SCC highest	28.02 ^c	0.40	4.12 ^b	0.06	3.34 ^c	0.02	4.61 ^d	0.01	1.24	0.01		

Note: a,b,c,d – means with different letter within column and factor significantly differs at $p < 0.05$.

CONCLUSION

At the studied farm level, the season, parity, and stage of lactation significantly influenced milk performance and SCC. Seasons showed unbalanced milk production, milk components, and also SCC throughout the study period. The SCC significantly increased with parity and was highest at the beginning and at the end of lactation. The SCC significantly reduced milk yield and lactose but increased fat and protein content in milk. Processing the data from the recording test days and their implementation at the farm level could contribute to better managing animal breeding.

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