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FACTORS AFFECTING SOMATIC CELL COUNT AND TOTAL MICROORGANISMS COUNT IN COW'S MILK

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Key words: cow milk, somatic cell count, total microorganisms count

The aim of this study was to analyse the effects of environmental factors on somatic cell count (SCC) and total microorganisms count (TMC) in cow bulk tank milk. The investigations were carried out in 2003 in 200 farms, situated in the Wielkopolska region.

In the period from May to September, higher levels of SCC and TMC in milk were observed than in the other months. The average number of cows in the herd was positively correlated (*i.e.* disadvantageously) with the level of SCC.

The following management and technological factors decreased both the level of SCC and TMC: keeping cows without pigs in the same farm, pre-milking udder and teat cleaning with a dry towel, use of antibiotics at cow dry-off, individual registration of the cases of clinical mastitis, antibiotic treatment of all cows with the clinical manifestation of mastitis, and pre-treatment performing of antibiogrammes in mastitic cows.

Furthermore, a decreased level of SCC was associated with the following factors: use of cow-runs in the summer season, use of California Mastitis Test, and use of concentrates in the amount greater than 4 kg per cow/day. A decreased level of TMC was observed in the herds in which cow-runs were not used in the winter season, pipe-line system of milking was used, milking cluster was stored between milkings dry or it was dipped in the water containing a disinfectant, disinfection of all stalls for cows was performed at least once per year, and sugar beet leaves were not used in cow feeding.

INTRODUCTION

Somatic cell count (SCC) and total microorganisms count (TMC) are the most important criteria of the hygienic quality of raw milk. SCC reflects the health status of the udder, as the major factor causing an increased level are inflammations of this gland caused by infections (mastitis). As opposed to SCC, the TMC is affected both by microbiological status of the udder, as well as hygienic conditions at milking and during milk storage.

After the accession of Poland to the EU, the regulations in force in the EU countries have been imposed, according to which raw milk has been classified as suitable (up to 400 000 somatic cells and 100 000 microorganisms per 1 cm^3) or unsuitable for processing (one or both parameters above the specified level). As milk production is the most important branch of the agricultural sector in Poland, the production of this raw material with low SCC and TMC is a matter of utmost concern both for the producers and processing companies. This resulted in a series of research studies [*e.g.* Skrzypek, 2002, 2003; Skrzypek & Kujawa-Kroll, 2002; Skrzypek & Szeląg-Gruszka, 2002; Skrzypek *et al.*, 2003a, b, 2004; Kamieniecki *et al.*, 2004] that analysed effects of selected factors on SCC and TMC under the production conditions. However, these studies were conducted in a limited number of herds, hence their results were often inconsistent.

Therefore, the aim of this paper was to analyse the effect of a wide spectrum of the environmental factors on SCC and TMC in a large group of farms.

MATERIAL AND METHODS

The investigations were carried out in 200 randomly selected farms, situated in the south-western part of the Wielkopolska region. All the farms supplied milk to the Dairy Cooperative of Gostyń. In the analysed farms, in the period between November 2003 and February 2004, recordings were carried out using a questionnaire consisting of more than 60 questions, divided into the following sections: general management, facilities for cows, availability of runs and pastures for cows, dry period management, hygienic conditions of milking, prophylaxis of the udder and teats, correction of hoofs, treatment and strategy of culling cows suffering from mastitis, feeding cows, and management of the replacement heifers beginning from the day of birth. Thereafter, using the database of the dairy, data on SCC and TMC in bulk tank milk was collected for the whole period of 2003. Laboratory analyses were performed for each farm twice a month, using the Fossomatic counter (Foss

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Electric, Hillerød, Denmark) and the standard plate count method [PN–A–86002, 1999] for SCC and TMC determinations, respectively.

Statistical calculations were performed using the multivariate analysis of variance with the GLM procedure [SAS® User's Guide, 1996]. Before the analysis, monthly weighted arithmetic means were calculated for SCC and TMC. Thereafter, the obtained values were transformed by the natural logarithm. This approach was recommended by Ali & Shook [1980] and has been widely used, for it increases sensitivity of the statistical test owing to the normalization of data distribution. In the statistical model, apart from the management and technological factors, the effects of the season (January, ..., December) and the average number of cows in the herd (up to 10, from 11 to 20, over 20) were included as well. Among the management and technological factors, a statistical analysis was performed on those that were found in at least 2 variants in the investigated farms, and if a given variant comprised more than 10 farms. The analysis of variance was performed in such a way that terms with the highest probability of the null hypothesis were stepwise eliminated from the model, leaving only those that were significant at $p \leq 0.01$ or $p \leq 0.05$. The results of analysis of variance are presented as least squares means.

RESULTS AND DISCUSSION

In the investigated farms, the arithmetic means for herd size, and SCC and TMC were 28.7 (sd=43.2) cows, and 268 000 (sd=101 000) and 44 000 (sd=39 000) cells per 1 cm^3 of milk, respectively. Thus, in the pre-accession year to the EU average herd size was much higher than the country average and both SCC and TMC were in accordance with present UE requirements, therefore all the milk could have been classified as suitable for processing. Although the correlation coefficient between SCC and TMC was significant, it was rather low (r=0.24), which confirms that both features should be employed simultaneously for the appropriate evaluation of the hygienic quality of raw milk.

In the period from May to September, higher ($p \leq 0.01$)

TABLE 1. Least squares means for factors affecting significantly the somatic cell count (SCC) and total microorganisms count (TMC) in milk.

Factors and their description		Number of herds	LogSCC	LogTMC
Average number of cows in the herd	3–10	41	12.28^{Aa}	ns
	11–20	103	12.34^{Ab}	ns
	21–345	56	12.57^{B}	ns
Keeping pigs in the same farm as cows	No	71	12.36^{A}	11.11^{A}
	Yes	129	12.43^{B}	11.25^{B}
Use of cow-runs in the winter season	No	189	ns	11.04^{A}
	Yes	11	ns	11.32^{B}
Use of cow-runs in the summer season	No	118	12.44^{A}	ns
	Yes	82	12.35^{B}	ns
System of milking	Can	140	ns	11.31^{A}
	Pipe-line	60	ns	11.05^{B}
Storing of the milking cluster between milkings	Dry	124	ns	11.02^{A}
	Dipping in water containing a disinfectant	59	ns	11.09^{A}
	Dipping in clean water (without a disinfectant)	17	ns	11.42^{B}
Disinfection of stalls for cows (at least once per year)	No	34	ns	11.39^{A}
	Yes	166	ns	10.97^{B}
Use of California Mastitis Test	No	32	12.46^{A}	ns
	Yes	168	12.33^{B}	ns
Use of antibiotics at cow dry-off	No	44	12.47^{A}	11.41^{A}
	Yes	156	12.32^{B}	10.95^{B}
Individual registration of the clinical cases of mastitis	No	128	12.50^{A}	11.25^{A}
	Yes	72	12.29^{B}	11.11^{B}
Treatment of the clinical cases of mastitis with antibiotics	All cows	100	12.46^{A}	11.25^{A}
	Selected cows	100	12.33^{B}	11.11^{B}
Pre-treatment performing of antibiogrammes in mastitic cows	No	112	12.46^{A}	11.26^{A}
	Yes	88	12.33^{B}	11.10^{B}
Average amount of concentrate fed per cow/day	≤4 kg	78	12.43^{A}	ns
	>4 kg	122	12.36^{B}	ns
Use of sugar beet leaves in cow feeding	No	137	ns	11.04^{A}
	Yes	63	ns	11.32^{B}

ABab – data marked with different letters are significantly different: capital letters – $p \leq 0.01$, small letters – $p \leq 0.05$. NS – non-significant differences

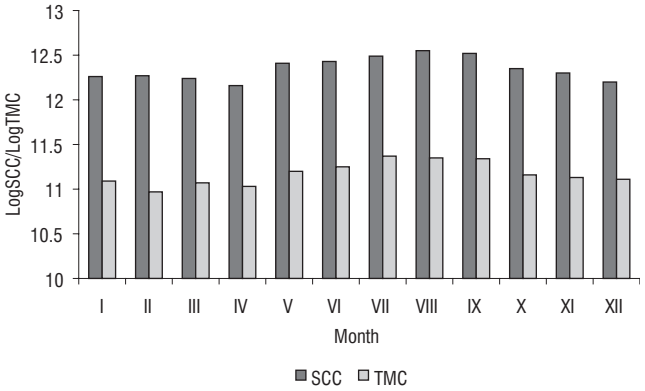

FIGURE 1. Effect of time of the year on somatic cell count (SCC) and total microorganism count (TMC) in milk. Results are expressed as least squares means.

levels of both SCC and TMC were observed compared to other months (Figure 1). In the studies conducted recently in Poland, similar effects of season were found [Skrzypek & Szeląg-Gruszka, 2002; Skrzypek *et al.*, 2004].

The average number of cows in the herd was positively correlated (*i.e.* disadvantageously) with the level of SCC (Table 1). A similar relationship was observed in other studies conducted in Poland, both in Wielkopolska [Skrzypek & Kujawa-Kroll, 2002; Skrzypek *et al.*, 2004] and West Pomerania [Skrzypek *et al.*, 2003 a]. Skrzypek *et al.* [2004] advanced a hypothesis that this relationship could be explained by the fact that along with the increase in herd size the risk of infectious diseases, including mastitis, increases as well. These authors also suggested that another reason may be the fact that in small herds fewer cows are handled by one person, and animals are treated more individually than in larger herds.

Both SCC and TMC were higher in the farms in which, apart from cows, pigs were kept as well. Skrzypek [2003] found a similar relationship for TMC. It is worthy to mention that UE directives forbid keeping other animals in the buildings in which dairy cows are housed or milked. Thus, results of the present study confirm that this approach is justified also in the Polish conditions, although all the interviewed farmers who housed pigs in their farms declared that these animals were maintained in separate buildings.

Use of cow-runs decreased SCC in the summer season, but increased TMC in the winter season. Kamieniecki *et al.* [2004] showed a similar effect of cow-runs in the summer season on SCC. These authors suggest that it can result from a positive effect of this system on the animal hygiene and welfare compared to other options of cow management in this season of the year. Contrary to the summer season, in the studies carried out in other farms and years [Skrzypek, 2002, 2003; Skrzypek & Kujawa-Kroll, 2002; Skrzypek & Szeląg-Gruszka, 2002; Skrzypek *et al.*, 2003a, b, 2004; Kamieniecki *et al.*, 2004] no effect was shown of using cow-runs during the winter season on the microbiological quality of milk. Thus, it can be assumed that this effect is strongly dependent on the hygienic conditions prevailing on the cow-run and/or the weather in a particular year.

The pipe-line system of milking was associated with a lower TMC, as compared with the can system. The main reason for this relationship was probably the fact that the pipeline system minimizes the contact of the milked milk with the external environment just after milking and during the transportation of milk from the cow to the tank. A favourable effect of the pipe-line system of milking on the microbiological quality of milk was also found in the studies of Skrzypek [2002, 2003].

Storing the milking cluster dry between milkings or dipping it in the water containing a disinfectant substantially decreased TMC compared to dipping in the clean water. An acceptable explanation of the observed relationship seems to be that dipping of the milking cluster in clean water causes its contamination by the microorganisms present and developing freely in the water not containing a disinfectant.

Disinfection of stalls for cows appeared to be one of the most important factors related to lower TMC. Similar effect was observed in the studies of Skrzypek & Kujawa-Kroll [2002] and Skrzypek & Szeląg-Gruszka [2002]. Furthermore, Barkema *et al.* [1998] reported a positive relationship between the frequency of stall disinfection and udder health.

Use of California Mastitis Test (CMT) decreased SCC. In Poland, the efficacy of CMT in decreasing the level of SCC was also evaluated in the study of Skrzypek *et al.* [2003 a].

The method of udder and teat cleaning before milking had significant effects on both SCC and TMC (Figure 2). The lowest values of these parameters were found in the group in which method 2 (wiping with dry towel) was used, whereas the highest SCC was in group 1 (no cleaning). The highest TMC was in group 5 (washing with water containing a disinfectant). Relatively low values of TMC were also found in groups 1 (no cleaning) and 4 (washing with clean water not containing a disinfectant). Similar distribution of particular methods of udder preparation for milking, which occurred in the investigated herds in spite of their random selection, confirms the fact that producers do not have a definite opinion on the optimum method of pre-milking udder and teat cleaning. Based on the results of this study, cleaning with a dry towel (paper or cotton) could be recommended as the best method for most of cows in the herd,

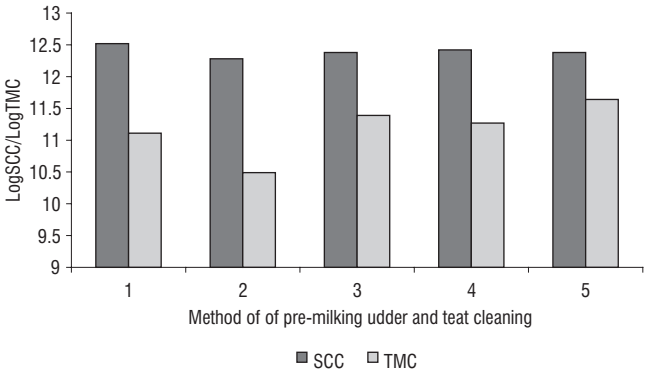

FIGURE 2. Effect of the method of pre-milking udder and teat cleaning on somatic cell count (SCC) and total microorganism count (TMC) in milk: 1 – no cleaning (n=35), 2 – dry towel (n=39), 3 – wet towel soaked with a disinfectant, dry towel (n=31), 4 – clean water, dry towel (n=55), 5 – water containing a disinfectant, dry towel (n=40). Results are expressed as least squares means. All the differences among groups are significant ($p \leq 0.01$), except for those among groups 3, 4 and 5 for SCC.

while the best method for extremely dirty cows would be washing with clean water. Results of the studies carried out in Poland [Skrzypek & Kujawa-Kroll, 2002; Skrzypek *et al.*, 2003b] that compared the same methods of udder and teat cleaning before milking showed that taking into account TMC the best method was also the use of a dry towel, whereas wiping with a wet towel appeared to be the best method for decreasing SCC and wiping with a dry towel ranked on the second place. It is believed that a low TMC in the milk of cows, in which pre-milking cleaning the udder and teats with a dry towel is used, results from the fact that this method inhibits the transfer of microorganisms from the central and upper part of the teat, as well as from the udder to the teat end and, as a consequence, to the milked milk [Rasmussen, 2000]. The same author claims that wiping the udder and teats with a dry towel or a towel soaked with a disinfectant are the best methods for decreasing SCC in milk, because washing makes that the udder and teats are wetter at the moment the milking is initiated, and this causes more frequent disturbances in the course of milking and thereby more frequent mechanical damage of the udder.

The use of antibiotics at cow dry-off decreased both SCC and TMC (Table 1). According to current knowledge, presented in the review articles of Barrett [2002] and Dinsmore [2002], the onset of dry period is under particular risk for contracting new intramammary infections. This risk is increased by transient decrease of cow immunity to infectious disease in the whole dry period. Because of these reasons, use of antibiotics at dry-off is recommended in all cows or even better in the cows under an elevated risk for mastitis (older animals or those with a history of the disease). Barkema *et al.* [1998] report a decreasing effect of this routine on SCC level in bulk tank milk, whereas Kamieniecki *et al.* [2004] report a similar effect on TMC. Although results obtained in this and other studies are clear, it has to be pointed out that the use of antibiotics for disease prevention in livestock receives increasing public concern about the development of antibiotic resistance in the treated animals and, consequently, in the consumers. Skrzypek [1996], Malinowski *et al.* [1997] and Myllys *et al.* [1998] consistently inform on markedly growing resistance of the pathogens causing mastitis against a given antibiotic.

Three routines (*i.e.* individual registration of the cases of clinical mastitis, treatment of all clinical mastitis cases with antibiotics, performing antibiogrammes in mastitic cows) were associated with a decreased SCC and TMC. Barrett [2002] and Skrzypek & Szeląg-Gruszka [2002] report a similar effect of the last two procedures on SCC, whereas there is no literature information on effects of the first procedure. Higher hygienic quality of milk from the farms in which the cases of clinical mastitis were individually registered could have been a result of the fact that it was helpful in prevention and treatment of the reoccurring cases. Numerous authors [Skrzypek, 1996; Malinowski *et al.*, 1997; Barkema *et al.*, 1998; Myllys *et al.*, 1998; Barrett, 2002] recommend reasonable use of antibiotics for the treatment of mastitis with the procedure designed based on microbiological findings of the sample and susceptibility of the pathogens to antibiotics. Results of this study clearly support such an approach.

Higher amount of concentrates offered per cow daily (>4 kg) compared to the lower level (≤4 kg) was associated with a lower SCC, which is in agreement with the results of two other studies that were carried in Poland [Skrzypek *et al.*, 2003a; Kamieniecki *et al.*, 2004]. It seems that it was related to higher energy intake in the herds in which higher level of concentrates was fed, as Suriyasathaporn *et al.* [2000] found that energy deficiency reduces the resistance of mammary gland to infection and increases the SCC.

Another feeding factor associated with the hygienic quality of milk (TMC) was the use of sugar beet leaves in cow feeding. Skrzypek [2002], who made a similar observation, hypothesizes that this relationship is a result of typically poor hygienic quality of this feed.

CONCLUSIONS

1. In the period from May to September higher levels of SCC and TMC in milk were observed than in other months.
2. The average number of cows in the herd was positively correlated (*i.e.* disadvantageously) with the level of SCC.
3. The following management and technological factors decreased both the level of SCC and TMC: (i) keeping cows without pigs in the same farm, (ii) pre-milking udder and teat cleaning with a dry towel, (iii) use of antibiotics at cow dry-off, (iv) individual registration of the cases of clinical mastitis, (v) antibiotic treatment of all cows with the clinical form of mastitis, and (vi) pre-treatment performing of antibiogrammes in the mastitic cows.
4. Furthermore, a decreased level of SCC in milk was associated with the following factors: use of cow-runs in the summer season, use of California Mastitis Test, and use of concentrates in the amount greater than 4 kg per cow/day. A decreased level of TMC in milk was observed in the herds in which cow-runs were not used in the winter season, the pipeline system of milking was used, milking cluster was stored dry between milkings or it was dipped in water containing a disinfectant, disinfection of all stalls for cows was performed at least once per year, sugar beet leaves were not used in cow feeding.

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CZYNNIKI WPŁYWAJĄCE NA LICZBĘ KOMÓREK SOMATYCZNYCH I OGÓLNĄ LICZBĘ DROBNOUSTROJÓW W MLEKU KROWIM

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Celem niniejszych badań była analiza wpływu czynników środowiskowych na liczbę komórek somatycznych (LKS) i ogólną liczbę drobnoustrojów (OLD) w mleku krowim zbiorczym. Badania przeprowadzono w roku 2003 w 200 gospodarstwach usytuowanych w południowo-zachodniej części Wielkopolski, dostarczających mleko do Spółdzielni Mleczarskiej w Gostyniu.

Od maja do września obserwowano wyższy poziom LKS i OLD niż w pozostałych miesiącach (rys. 1). Średnia liczba krów w stadzie była skorelowana dodatnio (tzn. niekorzystnie) z poziomem LKS (tab. 1).

Następujące czynniki organizacyjne i technologiczne obniżały zarówno poziom LKS jak i OLD: utrzymywanie krów bez świń w tym samym gospodarstwie, czyszczenie wymienia i strzyków przed dojem za pomocą suchego ręcznika, stosowanie antybiotyków przy zasuszaniu krów, indywidualna rejestracja klinicznych przypadków mastitis, leczenie antybiotykami wszystkich krów chorych na kliniczną postać mastitis, oraz wykonywanie antybiogramów przed leczeniem krów chorych na mastitis (tab. 1, rys. 2).

Oprócz tego, obniżony poziom LKS był związany z następującymi czynnikami: stosowanie wybiegów dla krów w sezonie letnim, stosowanie testu kalifornijskiego na mastitis, oraz stosowanie pasz treściwych w ilości większej niż 4 kg na krowę/dzień (tab. 1). Natomiast obniżony poziom OLD obserwowano w stadach, w których w sezonie zimowym nie stosowanie wybiegów dla krów, stosowano rurociągowy system doju, kubki udojowe były przechowywane między udojami na sucho lub zanurzano je w wodzie zawierającej środek dezynfekcyjny, w żywieniu krów nie stosowano liści z buraków cukrowych.