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INTERRELATIONS BETWEEN YEAR SEASON AND RAW MILK HYGIENIC QUALITY INDICES

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ABSTRACT

The aim of this study was to evaluate milk hygienic quality and to determine a relationship between season of year and raw milk quality indices. The experiment was carried out on 38 samples of milk collected from 80 high–production cows managed in a leading cattle breeding centre in south–west Poland. The analysis comprised total bacteria count, somatic cell count in 1 cm^3 of milk, chemical composition assay, i.e. fat and protein content, freezing point determination and test for inhibitory substances. The quality of milk was evaluated instrumentally, and the analysis for inhibitory substances was done using Delwotest assay. Both chemical composition and

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hygienic quality were within the standard set for the Extra class of raw milk. The season of year significantly influenced the chemical composition of milk and somatic cell count, however, it has no effect on freezing point or total bacteria count. Phenotypic correlations (at $p < 0.01$) between the season of year and milk fat or protein content were negative (respectively $r = -0.533$ and $r = -0.386$). A positive correlation (at $p < 0.05$) was observed between fat content and protein content ($r = 0.410$). The possibility exists to obtain high quality milk from high–production cows "in the studied herd", despite the season.

Key words: cows, raw milk composition, bacteria count, somatic cells, inhibitory substances, milk freezing point

INTRODUCTION

Milk quality is influenced by all the factors of the environment in which cows are kept and milked. An improvement of raw milk quality is now a necessity for the producers to survive in the increasingly competitive dairy market. The problem of enhancement of both the chemical composition and some technological parameters of milk holds strong interest for milk producers (sale price of raw milk), dairy technologists (processing costs) and consumers (dietary and health safety aspects).

In the light of current regulations, classification of raw milk consists in somatic cell count, bacteria count, determination of freezing point and examination for undesirable inhibitory substances (21,22). According to the Polish Standard [22], which has been in force since 1 January 1998, three quality classes (Extra, I and II) are applicable for the classification and payment for raw milk supplied to a purchasing dairy. The Extra class covers the milk with the following characteristics: total bacteria count is not higher than $100 \times 10^{3} \cdot cm^{-3}$, somatic sell count not higher than $400 \times 10^{3} \cdot cm^{-3}$ and freezing point is not higher then –0,512°C. A presence of inhibitory substances is unacceptable.

The results of the studies that have been carried on in Poland demonstrate a considerable variation in the composition [1, 8, 9] and hygienic quality [1–6, 8–10, 18] of milk supplied to dairy processing plants. An analysis of the factors that influence the hygienic quality of milk, and determination of their interactions, can be used as the basis for efficient action aimed at raw milk quality improvement.

The aim of this study was to estimate the hygienic quality of raw milk collected from cows kept in good sanitary and veterinary conditions in the leading dairy cattle breeding centres in south–west Poland during different seasons and to investigate whether or not the quality indices depend on the season of year.

MATERIALS AND METHODS

The material for the study comprised 38 samples of bulk–tank milk from a farm specialising in dairy cattle production in south–west Poland. The examined milk was collected from 80 Black–and–White cows with a high share of HF cattle genes. The annual milk yield exceeded 9.500 kg per cow. The herd was managed in tie stall barn under permanent veterinary supervision. The sanitary conditions of milking were good: the cows were milked by machine and the milk was cooled using DeLaval equipment, which allowed milk cooling to 3–4°C. The samples were randomly collected 3–4 times a month during milk receipt from the supplier, according to accepted sampling rules [24]. The analyses of the milk samples were for fat and protein content, freezing point (FP) and somatic cell count (SCC) with use of CombiFoss instrument (Foss Electric). Total bacteria count (TBC), expressed in colony–

forming units per cm^3 (CFU·cm^{-3}), was determined using BactoScan instrument (Foss Electric). Presence of antibiotics, sulphonamides or other inhibitory substances (IS) was tested with standard diffusive assay Delvotest (DSM Food Specialties) according to Polish Standards [23].

The results of the analyses from consecutive months, from December 1999 till November 2000, as well as from all the seasons (winter: December–February, spring: March–May, summer: June–August, autumn: September–November) were statistically analysed. Calculated were mean values ($\bar{\bar{x}}$), standard deviations (SD), coefficients of variability (V) and coefficients of phenotypic correlation. Analysis of variance was applied as well as Duncan test [15].

RESULTS

The pattern of changes in the studied raw milk characteristics is presented in Table 1 and Figures 1–5. During the examined period, the average fat and protein content was high (4.22% of fat and 3.44% of protein) with their low variability (respectively 5.2% and 4.6%). The extreme levels of milk fat content were recorded in November and February – respectively 3.98% and 4.56% (Figure 1). The extreme values of protein content, 3.17% and 3.60%, appeared in October and March, respectively (Figure 2). Freezing point remained very steady (V = 1.9%) and was –0.528°C; the extreme values were in February (–0.533°C) and in July (–0.523°C) (Figure 3). Total bacteria count in milk (V = 81.6%) was a parameter approx. threefold less stable than somatic cell count (V = 34.5%). Mean somatic cell count was 232.9·10^3·cm^{-3}; the extreme values were observed in October (113.7×10^3·cm^{-3}) and June (316.7×10^3·cm^{-3}) (Figure 4). Bacterial contamination of milk was low – average total bacteria count was 15.8×10^3 CFU·cm^{-3}; minimal values were recorded in February, April, July, August and October (10.0×10^3 CFU·cm^{-3}), whereas the maximum was in June (30.7×10^3 CFU·cm^{-3}) (Figure 5). No inhibitory substances were detected in the studied samples.

Table 1. Values of examined parameters in raw milk (n = 38)

Parameters	($\bar{\bar{x}}$)	SD	V %
Fat content [%]	4.22	0.22	5.2
Protein content [%]	3.44	0.16	4.6
Freezing point [°C]	–0.528	0.01	1.9
SCC [10^3·cm^{-3}]	232.9	80.4	34.5
TBC [10^3·cm^{-3}]	15.8	12.9	81.6
Inhibitory substances	ND*	–	–

*** ND – not detected.**

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Fig. 1. Fat content in milk during December 1999 - November 2000

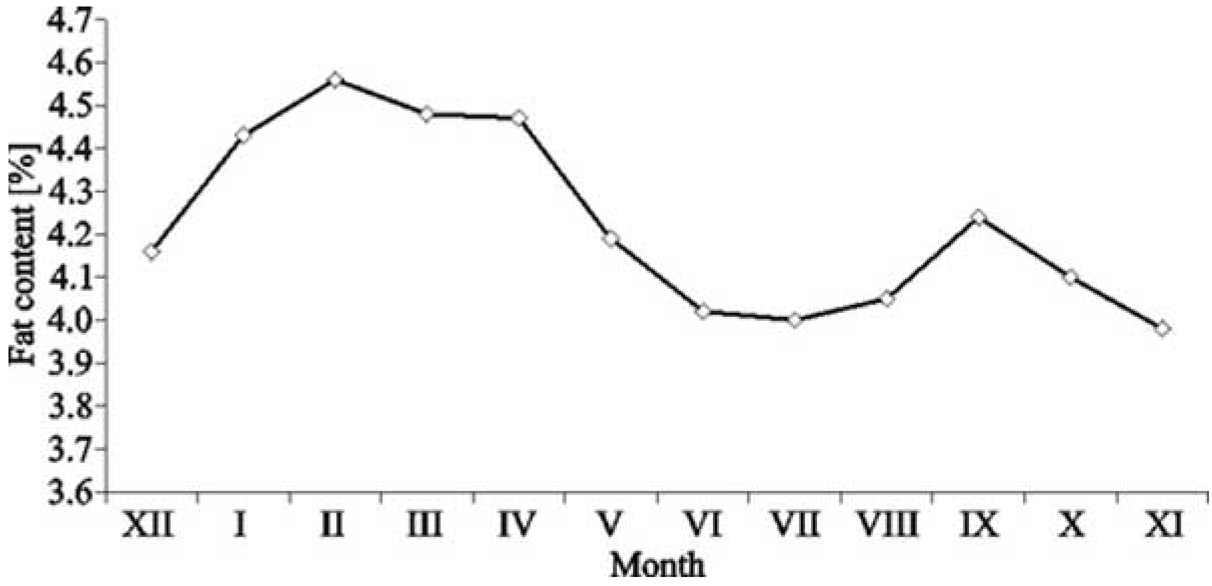

Fig. 2. Protein content in milk during December 1999 - November 2000

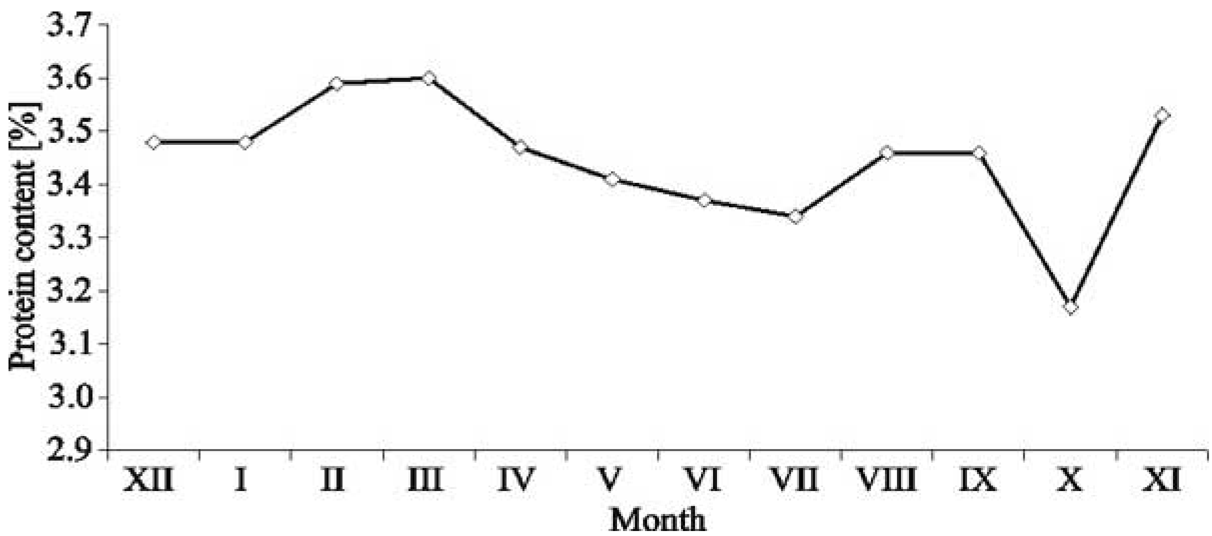

Fig. 3. Freezing point of milk during December 1999 - November 2000

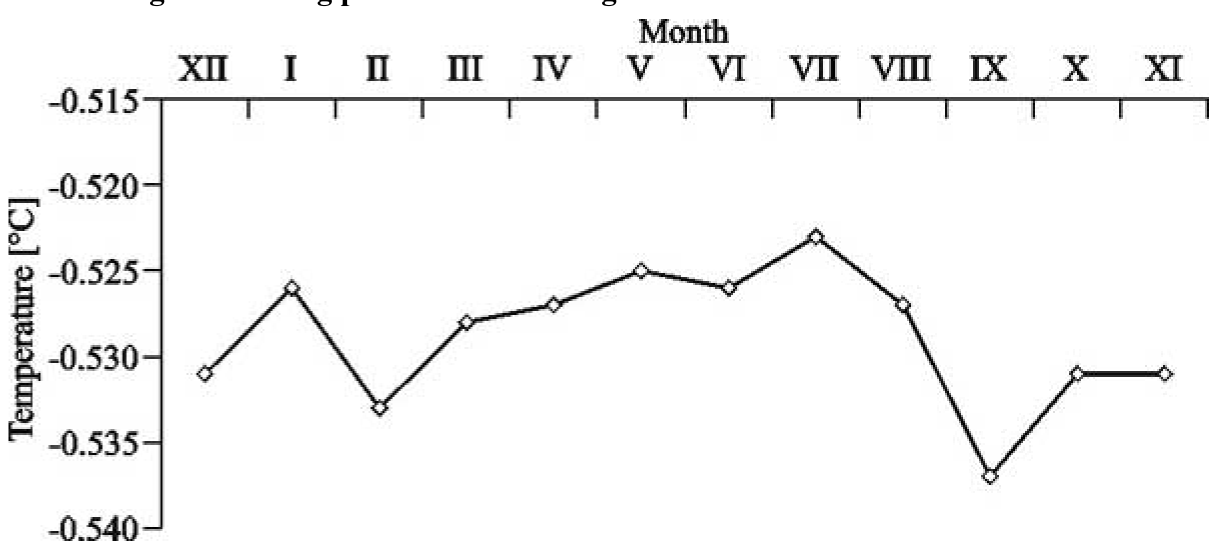

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Fig. 4. Somatic cell count in 1 cm3 of milk during December 1999 - November 2000

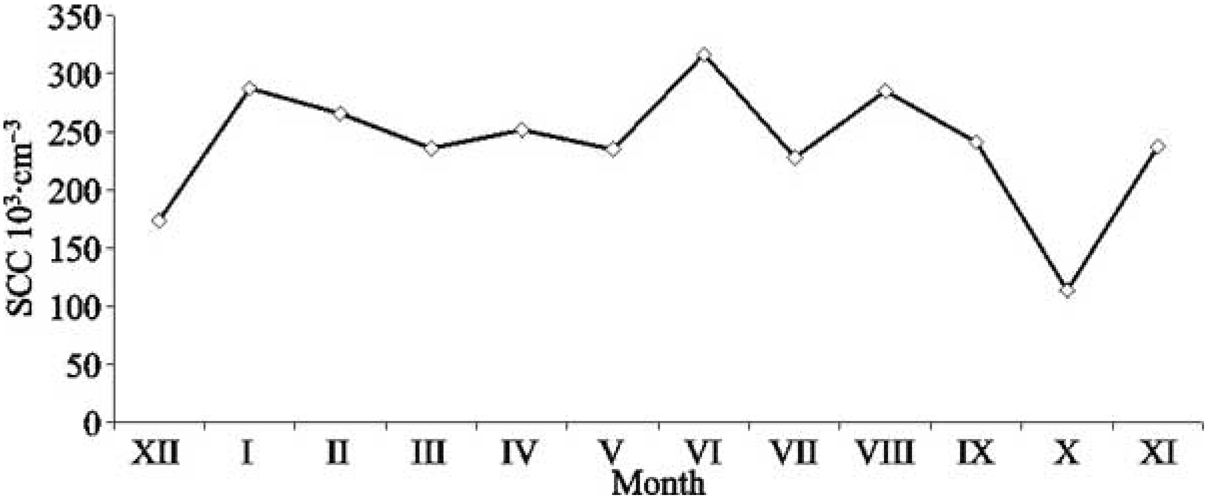

Fig. 5. Total bacteria count in 1 cm3 of milk during December 1999 - November 2000

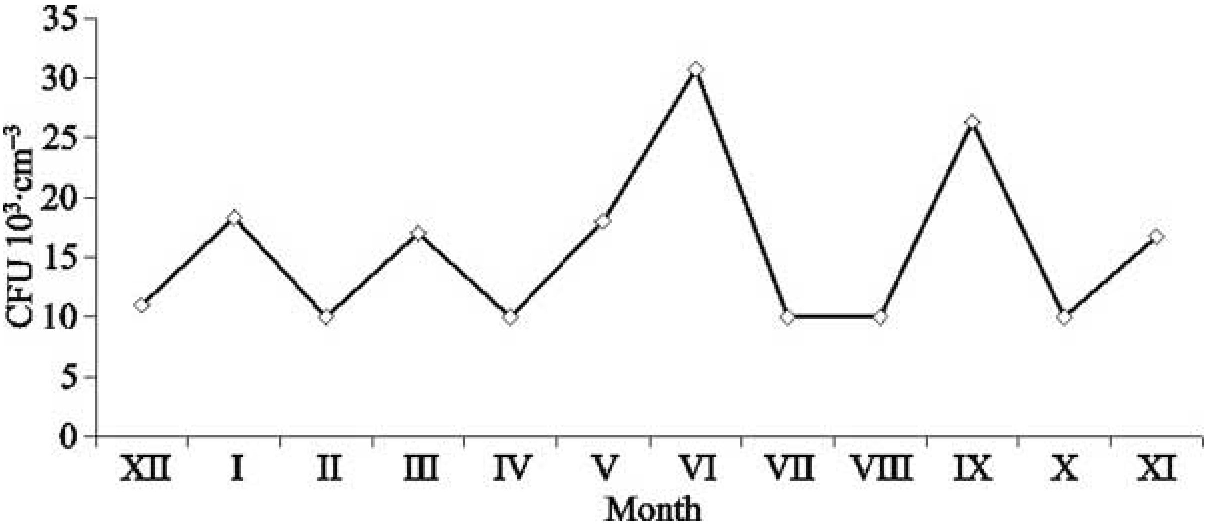

Table 2 presents the pattern of milk qualitative characteristics in relation to season of year. Statistical relationship ($p \leq 0.01$) was observed between fat content, protein content, SCC, and season of year. Statistically significant differences in milk fat content were observed between winter and summer, between winter and autumn, and between spring and summer. Protein level in milk differed statistically between spring and autumn. No significant effect of seasonality was observed on freezing point and total bacteria count.

Table 2. Influence of year season on the pattern of milk quality parameters (n = 38)

Month (season)	Statistical symbol	Fat content [%]	Protein content [%]	FP [°C]	SCC [$10^3 \cdot cm^{-3}$]	TBC [$10^3 \cdot cm^{-3}$]
XII–II (winter)	$\bar{x}$	4.34 ac	3.51	–0.528	231.8	13.2
	SD	0.22	0.07	0.005	89.8	8.2

III–V (spring)	$\bar{x}$	4.39 c	3.52 a	–0.527	238.5	15.9
	SD	0.20	0.11	0.007	39.5	12.7
VI–VII (summer)	$\bar{x}$	4.02 b	3.39	–0.525	276.8 a	16.9
	SD	0.11	0.07	0.005	93.0	15.3
IX–XI (autumn)	$\bar{x}$	4.11 b	3.37 b	–0.530	189.0 b	16.9
	SD	0.13	0.26	0.006	77.6	15.6

Description: a,b,c – means marked with different letters differ significantly at $p \le 0.01$.

In the summer, the highest somatic sell count ($276.8\times10^3\cdot cm^{-3}$) and bacteria count ($16.9\times10^3$ $CFU\cdot cm^{-3}$) were observed in the bulk–tank milk, along with the lowest fat (4.02%) and protein (3.39%) content, and with the highest value of freezing point (–0.525°C). In the winter, bacteria count (13.2×10^3 $CFU\cdot cm^{-3}$) was considerably lower than during the summer and autumn (16.6×10^3 $CFU\cdot cm^{-3}$).

Freezing point is one of the basic parameters of milk technological value. In the present study, the level of freezing point throughout the year ranged between –0.525°C (summer) and –0.530°C (winter).

Table 3 lists the coefficient of phenotypic correlation between the season of year and the studied parameters of raw milk quality. A significant negative relationship was observed between the season and fat content ($r = –0.533$; $p < 0.01$) and between the season and protein content ($r = 0.386$; $p < 0.05$). The season when the samples were collected did not significantly influence either freezing point ($r = –0.023$), somatic sell count ($r = –0.141$) or bacteria count ($r = 0.103$).

Table 3. Coefficients of phenotypic correlations between season of year and examined parameters of raw milk

Characteristic	2	3	4	5	6
Season of year	–0.533**	–0.386*	–0.023	–0.141	0.103
Fat content		0.410*	–0.005	0.130	–0.002
Protein content			0.176	0.289	0.022
Freezing point				–0.086	–0.079
SCC					0.114
TBC					

*** correlation significant at – $p < 0.05$.**
**** correlation highly significant at – $p < 0.01$.**

High, positive correlation ($p < 0.05$) was observed between protein content and fat content ($r = 0.410$). The growth of somatic sell number was accompanied by (statistically insignificant) increases in protein (r = 0.289) and fat (r = 0.130). With the increase in total bacteria count, somatic sell count grew as well (insignificantly, r = 0.114). The weakest relationship was demonstrated between protein content and total bacteria count (r = 0.022).

Very low and negative correlation was observed between fat content and freezing point (r = –0.005) as well as between fat content and total bacteria count (–0.002). Similar, low dependence was between freezing point and somatic cell (r = –0.086) and total bacteria count (r = 0.079).

DISCUSSION

Average chemical composition of bulk–tank milk during the period of the study was characterised by a very high fat (4.22%) and protein (3.44%) content. The observed favourable composition of milk may have resulted from proper feeding and from the cows' high breeding value. The milk chemical composition was similar to results presented in some papers [1, 8] and considerably exceeded the levels reported by other authors [6, 9]. According to another study, raw milk produced in south–west Poland contained 4.06% of fat and 3.22% of protein [9]. The results of the analyses of this material demonstrate the variability of milk quality evaluated in different seasons. The presented results are convergent with the results by other authors [1, 8, 9], who observed a clear decrease in fat and protein content of bulk–tank milk in summer.

The freezing point demonstrated here did not exceed the perimeter value (–0.512) set by the Polish Standard [22]. The obtained results were similar to the data found in other papers [8], and were slightly higher than those reported by the authors [4] who, analysing changes in freezing point of milk from Black–and–White (BW) cows (–0.559°C), Holstein–Friesian (HF) cows (–0.548°C), and BW×HF crossbreeds (–0.551°C), did not demonstrate statistically significant differences in this respect. An analysis of udder soundness vs. season of year interaction demonstrated small and statistically insignificant differences in milk freezing point [17].

Cytological (SCC = $232.9\times10^{3}\cdot cm^{-3}$) and microbiological (TBC = 15×10^{3} $CFU\cdot cm^{-3}$) quality of milk was very high and fell within the limits applicable for the Extra class of raw milk [22]. The presented results may be due to proper maintenance, good hygienic conditions and adequate veterinary on–farm care. The evaluated quality parameters of raw milk were much better than those reported by other authors [3, 6, 9]. Some studies [6] demonstrated a highly significant influence of the season of year on somatic cell content in milk, whereas in other papers [8] such a relationship was not observed. According to available reference literature, the highest number of somatic cells in milk was observed in the spring–summer season [8], summer–autumn [1, 2, 6], autumn–winter [18], as well as in the winter [9]. Microbiological quality of milk was high and statistically unvaried in individual seasons. Similar observation was confirmed in the literature [3, 6, 8, 9]. Some authors (8) demonstrated that commercial milk collected in spring–summer season contained nearly 3 times as many bacteria (868.9×10^{3} $CFU\cdot cm^{-3}$) as that produced in autumn and winter, however, the differences were statistically insignificant.

No inhibitory substances were detected in the studied samples, which should be considered as a positive effect. Probably, this is a result of appropriate sanitary and veterinary supervision, within which regular examinations take place towards detection of the substances (antibiotics, disinfection chemicals) in milk. On some farms, despite rigorous sanitation, the presence of IS

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in milk has been detected [11]. The cited authors detected inhibitory substances in 0.6–2.0% of samples from farms of good sanitary conditions and in 4.0–12.2% of samples coming from the farms that disobeyed milking hygiene rules. The results of the studies carried out in Poland during 1995–1997 demonstrated the presence of inhibitory substances in 1.6–1.7% of samples from individual milk suppliers and in 4.7–6.4% of the samples from the bulk milk in collection centres [14].

The results of this study confirmed the existence of statistically significant relationship between chemical composition of milk and the season of year. Similar conclusions can be drawn from the results by other authors [1, 8, 16]; low, positive correlation was demonstrated between SCC and the content of fat or protein in milk. Opinions of the cited authors differ, when it comes to the content of basic milk components and relations between them. An increase in fat content of milk, as a symptom of deteriorating udder health condition, was observed by many authors [1, 16, 17, 20], however, a reverse trend was demonstrated by others [13].

The distinct increase in protein content along with the increase in SCC ($r = 0.289$), which was observed in this study, was also reported in other papers [1, 13, 16]. The genetic correlations between somatic cell count and the yield and content of milk fat and protein, computed by other authors (19), ranged between 0.0 and –0.13. Similar to demonstrated in own studies, the significant relationship between fat content and protein content ($r = 0.410$) remains in accordance with observations by other authors [7, 17].

The results of this study, as well as those reported in another paper [17], did not confirm any significant dependence between somatic cell count and freezing point of milk. On the other hand, other authors [5] proved a statistically significant correlation between milk freezing point and hygienic milk parameters (TBC and SCC) at the levels between $r = 0.197$ and $r = 0.297$. In other studies [12], milk freezing point was demonstrated to be significantly lower during winter feeding (–0.563°C) than during summer feeding season (–0.552°C).

CONCLUSIONS

1. Season of year significantly influenced chemical composition of milk and somatic cell count, however it had no effect on freezing point and total bacteria count.
2. Chemical composition of milk as well as its hygienic quality fell within the standards applicable for the Extra class of raw milk.
3. Relationships between the season of year and milk quality parameters, except for negative correlation between the season and fat and protein content, appeared insignificant.
4. The results of this study demonstrate that obtaining high quality milk from high–production cows in the studied farm is feasible despite the season of year.

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