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EFFECT OF SOME ENVIRONMENTAL FACTORS ON THE RELATIONSHIP BETWEEN CYTOLOGICAL QUALITY OF MILK AND MILK YIELD AND COMPOSITION

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Abstract. Cows from the active population of the Pomerania and Kujawy regions, calved in 1998–2002, were investigated. Statistical analyses were performed using information on milk yield, fat, protein and lactose content, and somatic cell count in the milk obtained from 846 343 test-day milkings. Correlations between LNSCC and milk traits were calculated within lactation number, stage of lactation, daily yield, season of the year, and herd size. Somatic cell count was found to have a highly significant effect on milk traits. This effect was negative for daily yield and lactose content, and positive for fat and protein content. Factors that have the strongest differentiating effect on the relationship between LNSCC and daily milk yield were the age of cows and lactation period. A stronger relationship was found between LNSCC and milk yield in older cows (>4 lactations) and in cows in the final period of lactation (>10 months). Season of the year had a weak differentiating effect on the relationship between LNSCC and daily yield and had a stronger effect on the relationships between LNSCC and fat and protein content. For LNSCC and fat content, the highest correlations were obtained in the autumn and winter months. For LNSCC and protein content, the correlations were highest in the spring and summer period.

Key words: cows, milk, somatic cells

INTRODUCTION

Milk quality depends primarily on environmental and production factors, which include the housing system, feeding, lactation number, stage of lactation, udder health, season of the year and herd size. Breeding work also has some effect, the rate of improvement depending, among others, on the correlation between individual milk traits. Many research findings show a statistically significant effect of somatic cell count (SCC) on the yield and composition of milk. When discussing the results of many studies by authors who analysed the relationship between somatic cell count and milk traits, Sender [2001] re-

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ported that genetic correlations between milk yield and somatic cell count range from –0.20 to 0.28 and fat and protein yield is lowly but positively correlated with somatic cell count. Large variation in the correlations results from differences between populations, lactation numbers and calculation methods. The knowledge of correlation coefficients and the factors that influence these coefficients enables breeders to improve milk quality. Because somatic cell count is one of the criteria for grading purchased milk [PN-A-86002 1999] as well as an important indicator of udder health [Malinowski 2001], the present study was carried out to determine relationships between the cytological quality of milk and milk yield and composition according to selected factors.

MATERIAL AND METHODS

Cows from the active population of the Pomerania and Kujawy regions, calved in 1998–2002, were investigated. Statistical analyses were performed using information on milk yield, fat, protein and lactose content, and somatic cell count in the milk obtained from 846 343 test-day milkings. During statistical analysis, empirical data on somatic cell count were converted into the natural logarithm of somatic cell count (LNSCC). The CORR procedure of the SAS packet was used in the calculations [SAS/STAT 1995]. Correlations between LNSCC and milk traits were calculated within the following factors: lactation number (1, 2, 3, 4 and >4 lactation), stage of lactation (≤ 100, 101–200, 201–300 and >300 days), daily yield (≤ 10, 10.1–15, 15.1–20, 20.1–25 and >25 kg milk), season of the year (winter, spring, summer and autumn), and herd size (≤ 10, 11–20, 21–100, 101–200 and >200 cows).

RESULTS AND DISCUSSION

Daily milk yield of the cows from the population studied was high, with relatively low uniformity of this trait (Table 1). The fat and protein content indicates that the milk was of good chemical quality. The LNSCC value corresponds to high cytological quality of milk (approx. 190 000 somatic cells per ml milk).

The coefficients of correlation estimated based on test-day milkings between LNSCC and milk yield and fat, protein and lactose percentage were -0.192^{xx}, 0.074^{xx}, 0.251^{xx} and -0.374^{xx}, respectively (Table 2). Considering the Guilford scale [1964], it is concluded that the relationship between LNSCC and fat content was not significant, while the relationships between LNSCC and milk yield and protein and lactose content were clear but small.

The low but highly significant ($P \leq 0.01$) negative correlation between LNSCC and milk yield (Table 2) is consistent with the findings of Mroczkowski et al. [1999], Mrode and Swanson [1996], Sawa and Oler [1999], Sender et al. [1996, 1998] and Neja [2003].

The relationship between LNSCC and fat content was positive and four times weaker than between LNSCC and protein content. The relationships between SCC and fat content obtained by other authors are inconclusive. The increase in fat content of cows' milk, par-

alleled by deteriorating udder health, was reported by Brzozowski et al. [1999], Neja [2003], Sawa and Oler [1999], and Sender et al. [1996]. A reverse trend was shown by Mroczkowski et al. [1999].

Table 1. Statistical characteristics of milk productivity traits of the cows
Tabela 1. Charakterystyka statystyczna cech mleczności krów

Statistic measures Miary statystyczne	Traits – Cechy				
	milk, kg mleko, kg	fat, % tłuszcz, %	protein, % białko, %	lactose, % laktoza, %	LNSCC
$\overline{X}$	17.30	4.30	3.33	4.72	12.15
CV, %	41.84	19.39	14.06	6.43	11.13

LNSCC – natural logarithm count of somatic cells.
LNSCC – logarytm naturalny liczby komórek somatycznych.
CV – coefficient of variation.
CV – współczynnik zmienności.

Table 2. Coefficients of correlation between the natural logarithm of somatic cell count and traits of test-day milk
Tabela 2. Wskaźniki korelacji pomiędzy logarytmem naturalnym liczby komórek somatycznych a cechami mleka z próbnych udojów

Analysis within Analiza w obrębie		No. of correlated pairs Liczba korelowanych par	LNSCC x milk, kg LNSCC x (mleko), kg	LNSCC x fat, % LNSCC x (tłuszcz), %	LNSCC x protein, % LNSCC x (białko), %	LNSCC x lactose, % LNSCC x (laktoza), %
Total – Populacja razem		846 343	–0.192^{xx}	0.074^{xx}	0.251^{xx}	–0.374^{xx}
Lactation number Numer laktacji	1	278 140	–0.142^{xx}	0.096^{xx}	0.242^{xx}	–0.291^{xx}
	2	203 826	–0.222^{xx}	0.085^{xx}	0.253^{xx}	–0.349^{xx}
	3	144 878	–0.237^{xx}	0.079^{xx}	0.257^{xx}	–0.363^{xx}
	4	96 177	–0.235^{xx}	0.072^{xx}	0.254^{xx}	–0.378^{xx}
	> 4	123 322	–0.258^{xx}	0.067^{xx}	0.249^{xx}	–0.389^{xx}
Phase of lactation, days Faza laktacji, dni	≤ 100	242 913	–0.069^{xx}	0.052^{xx}	0.183^{xx}	–0.317^{xx}
	101–200	252 651	–0.089^{xx}	0.023^{xx}	0.169^{xx}	–0.357^{xx}
	201–300	230 506	–0.147^{xx}	0.008^{xx}	0.179^{xx}	–0.374^{xx}
	> 300	120 273	–0.203^{xx}	0.001	0.179^{xx}	–0.393^{xx}
Daily yield, kg Dobowa wydajność, kg	≤ 10	133 959	–0.199^{xx}	0.017^{xx}	0.243^{xx}	–0.414^{xx}
	10.1–15	227 134	–0.049^{xx}	0.018^{xx}	0.183^{xx}	–0.339^{xx}
	15.1–20	223 610	–0.029^{xx}	0.027^{xx}	0.187^{xx}	–0.328^{xx}
	20.1–25	146 195	–0.020^{xx}	0.035^{xx}	0.174^{xx}	–0.323^{xx}
	>25	115 445	–0.023^{xx}	0.043^{xx}	0.164^{xx}	–0.276^{xx}
Season of the year Pora roku	Winter – Zima	218 729	–0.202^{xx}	0.061^{xx}	0.262^{xx}	–0.380^{xx}
	Spring – Wiosna	223 854	–0.178^{xx}	0.072^{xx}	0.229^{xx}	–0.364^{xx}
	Summer – Lato	182 239	–0.178^{xx}	0.098^{xx}	0.249^{xx}	–0.365^{xx}
	Autumn – Jesień	221 521	–0.206^{xx}	0.081^{xx}	0.271^{xx}	–0.394^{xx}
Number of cows Liczba krów	≤ 10	78 409	–0.195^{xx}	0.064^{xx}	0.246^{xx}	–0.375^{xx}
	11–20	256 084	–0.220^{xx}	0.087^{xx}	0.262^{xx}	–0.376^{xx}
	21–100	229 821	–0.219^{xx}	0.077^{xx}	0.248^{xx}	–0.377^{xx}
	101–200	169 690	–0.209^{xx}	0.064^{xx}	0.239^{xx}	–0.391^{xx}
	> 200	112 339	–0.273^{xx}	0.068^{xx}	0.227^{xx}	–0.421^{xx}

xx – $P \leq 0.001$.

A marked increase in milk protein content, paralleled by increasing somatic cell count, was reported by Brzozowski et al. [1999] and Neja [2003]. Kisza and Sajko [1987] point to an increase in protein content, which is undesirable in terms of consumption and processing because of the decreasing casein content (valuable protein) and the increasing amount of albumins and globulins (whey proteins). The correlation results obtained are within the range estimated by other authors [Mroczkowski et al. 1999; Mrode and Swanson 1996; Sender et al. 1996].

The closest and negative relationship was found between LNSCC and lactose content. The estimated coefficients of correlation correspond with the findings of other authors [Neja 2003; Górska 2004]. Lactose content is one of the parameters of health udder. The presence of bacterial pathogens increases the chloride content and reduces the lactose content.

Relationships between LNSCC and milk yield and lactose content were increasing in older cows. The higher decrease in daily milk yield together with the increase in milk somatic cell count, observed in older cows, is confirmed by the studies of Sawa et al. [2000] and Sender et al. [1998]. Mrode and Swanson [1996] and many authors cited by them reported higher correlation coefficients between LNSCC and milk yield in older cows than in first calvers. In the present study we showed that with the age of cows, the correlation between LNSCC and fat content decreased slightly. A different relationship was reported by Sender et al. [1998]. In our study, the weakest relationship between LNSCC and protein content was found in first calvers. This is consistent with the results of Sender et al. [1998] and contradicts the observations of Monardes and Hayes [1984].

In the study we also analysed the effect of lactation period on the relationships between traits. The relationship between somatic cell count and daily yield of cows in the final months of lactation (>300 days) was approximately three times greater that that in the first 100 days of lactation. No regular relationship was found for lactation progress to be paralleled by an increasing or decreasing relationship between LNSCC and protein content, Lactation progress was accompanied by a marked decrease in the relationship between LNSCC and fat content and an increase in the relationship between LNSCC and lactose content. When analysing relationships between somatic cell count and milk yield and composition in successive months of lactation, Neja [2003] found that the coefficients of correlation between LNSCC and milk yield and lactose content were negative, and their absolute values increased as lactation progressed.

For cows with a daily yield of up to 10 kg milk, there were much higher coefficients of correlation between LNSCC and milk yield, protein content and lactose content compared to those of higher yielding cows. Daily yield of over 10 kg milk had a low differentiating effect on the relationships between LNSCC and milk traits, with an upward tendency towards the relationship between LNSCC and fat content and a decrease in the relationship between LNSCC and protein and lactose content.

Considering the relationships between LNSCC and milk traits in particular seasons of the year, higher values were noted in autumn and winter than in spring and summer, and the greatest differences were found when evaluating the correlations between LNSCC and protein content (r = from 0.229^{xx} to 0.271^{xx}), followed by the correlations between LNSCC and fat content (r = from 0.061^{xx} to 0.098^{xx}). The relationship between LNSCC and daily

milk yield did not differ considerably within seasons of the year (correlations ranging from $–0.178^{xx}$ to $–0.206^{xx}$).

Analysis of the relationships between LNSCC and daily milk yield within herd size classes showed relatively high coefficients of correlation in herds with over 200 cows, which should motivate breeders to pay greater attention to udder health. The absolute values of the correlation coefficients between LNSCC and lactose content increased in larger herds from $–0.375^{xx}$ to $–0.421^{xx}$. Much smaller differences were found within herds for correlation coefficients between LNSCC and milk fat and protein content.

CONCLUSIONS

It is concluded that somatic cell count has a highly significant effect on milk traits. This effect is negative for daily yield and lactose content, and positive for fat and protein content. Factors that have the strongest differentiating effect on the relationship between LNSCC and daily milk yield were the age of cows and lactation period. A stronger relationship was found between LNSCC and milk yield in older cows (> 4 lactations) and in cows in the final period of lactation (>10 months). With progressing lactation and age of cows, there was a regular increase in the absolute values of correlation coefficients between LNSCC and lactose content, paralleled by a tendency towards a decreasing relationship between LNSCC and fat and protein content. Season of the year had a weak differentiating effect on the relationship between LNSCC and daily yield and had a stronger effect on the relationships between LNSCC and fat and protein content. For LNSCC and fat content, the highest correlations were obtained in the autumn and winter months. For LNSCC and protein content, the correlations were highest in the spring and summer period. Relatively high coefficients of correlation between LNSCC and milk yield in herds with more than 200 cows should encourage breeders to pay greater attention to udder health. Differences in the coefficients of correlation between LNSCC and milk traits within the age of cows, stage of lactation, herd size and season of the year show that these factors should be accounted for in activities aimed at increasing milk yield and improving milk quality.

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WPŁYW WYBRANYCH CZYNNIKÓW ŚRODOWISKOWYCH NA ZWIĄZEK MIĘDZY JAKOŚCIĄ CYTOLOGICZNĄ MLEKA A JEGO WYDAJNOŚCIĄ I SKŁADEM

Streszczenie. Badania przeprowadzono na krowach populacji aktywnej Pomorza i Kujaw, wycielonych w latach 1998–2002. Analizy statystyczne wykonano wykorzystując informacje o wydajności mleka, zawartości tłuszczu, białka i laktozy oraz liczbie komórek somatycznych

w mleku w 846 343 próbnych udojach. Korelacje pomiędzy LNSCC a cechami mleka liczono w obrębie numeru laktacji, fazy laktacji, wydajności dobowej, pory roku, liczebności stada. Wykazano, że istnieje wysoko istotny wpływ liczby komórek somatycznych na cechy mleka, ujemny w zakresie wydajności dobowej i zawartości laktozy oraz dodatni w przypadku zawartości tłuszczu i białka. Czynnikami najsilniej różnicującymi związek między LNSCC a dobową wydajnością mleka okazały się wiek krowy i okres laktacji. Wykazano silniejszy związek między LNSCC a wydajnością u krów starszych (> 4 laktacji) oraz będących w końcowym okresie laktacji (> 10 miesięcy). Pora roku w małym stopniu różnicowała zależność między LNSCC a wydajnością dobową, większy okazał się jej wpływ na zależności między LNSCC a zawartością tłuszczu i białka. W przypadku LNSCC i zawartości tłuszczu najwyższe korelacje uzyskano w miesiącach jesienno-zimowych, w przypadku LNSCC i zawartości białka – w okresie wiosenno-letnim.

Słowa kluczowe: komórki somatyczne, krowy, mleko

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