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Relationship between somatic cell count and milk performance of Polish Holstein-Friesian cows

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The average somatic cell count in the milk analysed was 326,000 cells/ml. For the 4 groups of cows distinguished in the study, with daily milk yield of ≤15 kg, 15-25 kg, 25-35 kg and >35 kg, the somatic cell count was 771,000, 393,000, 240,000 and 180,000 cells/ml, respectively. Statistical analysis revealed significant differences in the somatic cell count in milk from cows with different productivity. A highly significant correlation coefficient was obtained for the daily milk yield of the cows and the somatic cell count in the milk (r=−0.81). The negative coefficient indicates that an increase in the quantity of milk was accompanied by a decrease in the somatic cell count in the milk. The regression equation obtained suggests that in the study population a decline in somatic cell count of 100,000 cells/ml was accompanied by an increase in daily milk yield of 3.8 kg. The analysis showed that there is a negative correlation between SCC and milk yield of cows. An increase in milk yield was found to be accompanied by a decrease in the number of somatic cells in 1 ml of milk, which indicates an improvement in its quality.

KEY WORDS: somatic cells / milk yield / fat and protein content / correlation

Udder inflammation in cows (mastitis) is one of the main disease entities occurring in dairy cattle herds in Poland. Mastitis causes measurable economic losses and has a negative effect on milk quality [15]. A practical criterion used for many years to detect signs of udder inflammation is the somatic cell count in milk [4, 9, 11]. Mastitis arises mainly due to bacteria attacking the mammary gland. Other pathogenic agents include fungi, *Rickettsia*, viruses, parasitic protozoa, and algae [9]. The most dangerous aetiological agents are *Staphylococcus aureus*, streptococci, and *E. coli*, but the percentage of individual species is continually changing [15].

The aim of the study was to evaluate the correlations between somatic cell count and the milk performance of Polish Holstein-Friesian cows.

Material and methods

The data used in the study, from the years 2013-2014, pertained to three dairy cattle herds in the counties of Sokołów and Siedlce. The dairy cattle herds were subject to use value assessment by the Polish Federation of Cattle Breeders and Dairy Farmers (PFCBDF). Milk performance in the herds was assessed by the AT4 method. Data pertaining to 91 cows were used in the study. Two of the herds were housed in a tie-stall system and the third in a free-stall ball. In all barns the cows were milked twice a day: with pipeline milking machines in the tie-stall barns and in a milking parlour in the free-stall barn. In all of the barns feed was supplied using a feeding wagon.

The cow population was divided with respect to the following:

– production level, with the following groups distinguished according to daily milk yield: ≤15 kg, 15-25 kg, 25-35 kg and >35 kg;

– somatic cell count in 1 ml of milk: ≤200,000, 200,000-400,000, 400,000-600,000, 600-800 and >800,000.

The somatic cell count was transformed to a natural logarithm to meet the conditions of a normal distribution.

Analysis of variance by the least squares method was used for the statistical calculations. The following linear model was used:

$$Y_{ijkl} = \mu + a_i + b_j + c_k + (ab)_{ij} + e_{ijkl}$$

where:

Y_{ijkl} – value of the feature;
μ – mean for the population;
a_i – effect of *i*-th month of lactation (i = 1, … 10);
b_j – effect of *j*-th production level (j = 1, 2, 3, 4);
c_k – effect of *k*-th class of somatic cell count (k = 1, 2, … 5);
$(ab)_{ij}$ – interaction of month of lactation x production level;
e_{ijkl} – random error.

Significance of differences between pairs of means was estimated by Duncan's test at a significance level of P≤0.05. Correlation coefficients and linear regression were used to assess the correlations between somatic cell count and milk yield. The calculations were performed in Statistica 12.5.

Results and discussion

Table 1 presents data on the somatic cell count and log somatic cell count in each month of lactation, depending on the daily milk yield of the cows. The mean somatic cell count in the cow population was 326,000/ml. The lowest somatic cell count was noted in the three middle months of lactation, i.e. the sixth, seventh and eighth. A marked decrease in the number of somatic cells was observed as daily milk yield increased. For the four groups of cows distinguished in the study, with daily milk yield of ≤15 kg, 15-25 kg, 25-35 kg and >35 kg, the somatic cell count in 1 ml of milk was 771,000,

393,000, 240,000 and 180,000, respectively. Piwczyński [12] found that high yield is always accompanied by a low somatic cell count, and a decrease in yield is linked with an increased somatic cell count. According to many authors [3, 6, 7, 8] a high somatic cell count at the beginning and end of lactation is explained by the low milk yield at this time, while during peak yield the quantity of milk has a 'diluting' effect on somatic cells.

Table 1

Somatic cell count (SCC; 1,000/ml) and natural log-transformed SCC according to month of lactation and daily milk yield of cows

Month of lactation	Daily milk yield (kg)								Average	
	≤15		15-25		25-35		>35			
	LKS SCC	LnLKS LNSCC	LKS SCC	LnLKS LNSCC	LKS SCC	LnLKS LNSCC	LKS SCC	LnLKS LNSCC	LKS SCC	LnLKS LNSCC
1	128	4.85	602	5.69	321	4.86	86	4.02	302	4.76^{b}
2	677	5.99	382	5.24	412	4.48	183	4.23	348	4.66^{b}
3	–	–	426	5.03	217	4.50	397	4.82	333	4.75^{b}
4	1323	6.67	486	5.27	137	4.36	118	4.44	279	4.74^{b}
5	1046	6.30	519	5.15	325	4.89	104	4.38	402	$4,99^{b}$
6	531	5.90	294	4.94	124	4.37	214	4.58	236	4.75^{b}
7	794	6.44	280	5.05	168	4.40	127	4.40	278	4.90^{b}
8	890	6.48	224	4.85	171	4.65	52	3.75	246	4.80^{b}
9	915	6.67	527	5.11	131	4.64	61	4.11	454	5.14^{a}
10	1026	6.17	359	4.94	176	4.59	81	4.39	450	5.10^{a}
Average	771^{a}	6.12^{a}	393^{b}	5.11^{b}	240^{bc}	4.59^{c}	180^{c}	4.36^{c}	326	4.85

Mean values in column with different superscript letters differ statistically significantly at P≤0.05
Mean values in row with different superscript letters differ statistically significantly at P≤0.05

The effect of the class of somatic cell content in 1 ml of milk on milk yield was evaluated as well (Tab. 2). The somatic cell count, an indicator of the health of the cows, was shown to significantly affect daily milk yield in the population of 91 cows. The highest daily milk production was noted in healthy cows whose milk contained no more than 200,000 somatic cells per ml. The difference in milk yield between extreme classes of somatic cell content (≤200,000/ml and >800,000/ml) was as high as 8.7 kg of milk per day per cow. A study by Guliński et al. [5] conducted in five cow herds in southern Podlasie, based on lactation data from 1997-2000, confirms this correlation. Cows with the highest somatic cell count in 1 ml of milk produced on average 3.4 kg less milk than their contemporaries whose milk was of the best quality in terms of somatic cells.

Table 2
Changes in daily milk yield (kg) depending on somatic cell count in 1 ml of milk

Class of somatic cell count (1,000/ml)	n	Daily milk yield (kg)			
		mean	SD	min.	max.
≤200	533	30.3[a]	14.66	6.0	64.0
200-400	88	25.3[b]	10.07	9.6	53.2
400-600	51	23.6[b]	8.22	6.2	42.0
600-800	18	23.7[b]	6.12	13.4	32.0
>800	82	21.6[b]	8.47	4.2	44.0
Total/average	772	28.3	12.52	4.2	64.0

Mean values in column with different superscript letters differ statistically significantly at P≤0.05

Table 3 presents the correlation coefficient between daily milk yield and somatic cell count. The coefficient was high and negative, at r=−0.81. This means that as the somatic cell count increased there was a marked decrease in milk yield. The regression equation obtained indicates that a decrease in somatic cell count of 100,000/ml was accompanied by an increase in daily milk yield of 3.8 kg. In a study by Guliński et al. [5] the regression coefficient indicated that a 10 kg increase in daily milk yield was accompanied by a decrease in somatic cell count of 94,400.

Table 3
Correlation coefficient (r) and regression equation for somatic cell count in milk and daily milk yield

Correlated traits	Correlation coefficient (r)	Regression equation
Milk yield (x) and somatic cell count (y)	–0.81*	y = 433 – 3.8x

*Coefficient of correlation significant at P≤0.05

A negative correlation between somatic cell content and daily milk yield has also been shown by other authors [5, 7, 10, 14]. Jakiel et al. [7] obtained a negative but lower correlation coefficient, at –0.14.

Another element of the study was determination of the changes in the percentage content of fat, protein and lactose in the milk in relation to the somatic cell count in 1 ml of the milk (Tab. 4). The mean content of these milk components for the group analysed was 4.21%, 3.48% and 4.81%, respectively. No statistically significant effect of somatic cell

Table 4
Changes in the percentage of fat, protein and lactose in milk depending on somatic cell count in 1 ml of milk

Class of somatic cell count (1,000/ml)	n	Fat (%)	Protein (%)	Lactose (%)
≤200	533	4.14[a]	3.44[b]	4.85[a]
200-400	88	4.47[a]	3.57[ab]	4.79[a]
400-600	51	4.38[a]	3.66[a]	4.70[bc]
600-800	18	4.20[a]	3.41[b]	4.74[b]
>800	82	4.26[a]	3.56[ab]	4.65[c]
Total/average	772	4.21	3.48	4.81

Mean values in columns with different superscript letters differ statistically significantly at P≤0.05

count on fat content in the milk was observed. Many authors [2, 10, 12] have made similar observations regarding a lack of correlation between somatic cell count in milk and its fat content.

The effect of the level of somatic cells in milk on protein content was assessed as well (Tab. 4). The highest mean protein content (3.66%) was obtained for the class of 400,000--600,000 somatic cells in 1 ml of milk. This is confirmed in a study by Brzozowski et al. [3], who found the highest percentage content of protein in the milk of cows with an elevated somatic cell count. However, Sawa and Oler [13] state that increased protein content accompanying elevated somatic cell count is unfavourable in terms of milk processing. Substantial changes occur in milk protein, as the percentage of the most valuable protein (casein) decreases while that of whey proteins increases. An elevated somatic cell count in milk leads to prolonged clotting time, elevated curd moisture and reduced cheese yield, mainly due to a reduction in dry matter in the milk [1].

Increased somatic cell count was also found to be accompanied by a slight decrease in the concentration of lactose: from 4.85% to 4.65%. A study by Piwczyński [12] also indicates that a decrease in the percentage of lactose is linked to increased somatic cell count.

The somatic cell count in 1 ml of milk was observed to decrease as the daily milk yield of the cows increased. For the four groups of cows distinguished in the study, with daily milk yield of ≤15 kg, 15-25 kg, 25-35 kg and >35 kg, the somatic cell count in 1 ml of milk was 771,000, 393,000, 240,000 and 180,000, respectively. This correlation was confirmed by the correlation coefficient, which was statistically significant. The correlation coefficient for the daily milk yield of the cows and the somatic cell count in their milk was –0.81. The negative coefficient obtained indicates that an increase in milk yield was accompanied by a decrease in somatic cell count.

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