Comparison of selected milk production traits of Simmental and Polish Black-and-White cows raised in the buffer zone of Ujście Warty National Park

Piotr Sablik*, Małgorzata Szewczuk*, Ewa Januś**, and Anna Skrzypiec*

Abstract

In the study the qualitative and quantitative characteristics of milk obtained from Simmental cows imported from the Czech Republic (n = 63), their daughters born in Poland (n = 46), and cows of the Polish Black-and-White breed with up to 50 % Holstein-Friesian genes (n = 21) were compared. Actual milk yield, value-corrected milk (VCM) and energy-corrected milk (ECM), as well as fat and protein content in the milk, were compared in 305-day lactation for a one-year period. The udder health of cows was assessed on the basis of the somatic cell count (SCC) in the milk and the log-transformed somatic cell count (LnSCC). Polish Black-and-White cows had the highest actual milk yield and fat yield. Simmentals from the Czech Republic, on the other hand, had the highest average protein yield and the highest VCM yield. The season and the breed and origin of the cows were found to significantly affect the number of milk samples with an elevated SCC. Simmental cows born in Poland had significantly the lowest mean SCC and LnSCC, as compared to both the Czech Simmentals and the Black-and-White breed. The Simmental cows, although their milk yield was lower than that of the Black-and-White breed, had better udder health assessed on the basis of LnSCC and their milk had a more favourable protein-to-fat ratio. Simmental cows can be successfully used on farms adjacent to areas under environmental protection, where intensive agricultural production, including livestock farming, is prohibited.

Keywords: *Simmentals, Polish Black-and-White breed, milk yield, somatic cell count, VCM, ECM, cows*

Zusammenfassung

Vergleich ausgewählter Milchleistungsmerkmale von Fleckviehkühen und polnischen Schwarzbunten unter landwirtschaftlichen Bedingungen im Hinterland des Nationalparks „Ujście Warty“ (Warthe-Mündung)

In der Studie wurden quantitative und qualitative Milchmerkmale der aus Tschechien importierten Fleckvieh-Kühe (n = 63), ihrer in Polen geborenen Töchter (n = 46) und der polnischen Schwarzbunten Kühe mit einem Holstein-Friesisch-Genanteil von 50 % (n = 21) untersucht. Verglichen wurden tatsächliche Milchleistung, wertkorrigierte (VCM) und ECM-Milchleistung sowie Fett-und Proteingehalt in einer 305-Tage-Laktation innerhalb eines Jahres. Anhand der Zellzahl in der Milch und des natürlichen Logarithmus der Zellzahl (LnZZ) wurde die Eutergesundheit der Kühe verschiedener Rassen und Herkunft bewertet. Die polnischen Schwarzbunten Kühe erreichten die höchste tatsächliche Milch- und Fettleistung. Die Fleckvieh-Kühe aus Tschechien erreichten hingegen die höchste durchschnittliche Eiweißleistung und die höchste VCM-Milchleistung. Einen signifikanten Einfluss der Saison, Rasse und Herkunft der Kühe auf die Zahl der Milchproben mit erhöhter Zellzahl wurde nachgewiesen. Die in Polen geborenen Fleckvieh-Kühe charakterisierten sich durch signifikant niedrigste mittlere ZZ und LnZZ, verglichen mit der Schwarzbunten Rasse. Die Milchleistung lag bei den Fleckvieh-Kühen niedriger als bei den schwarzbunten Kühen, allerdings waren Eutergesundheit, gemessen anhand des LnZZ, und Eiweiß-Fett-Verhältnis besser. Die Fleckviehkühe können erfolgreich in ökologischen Regionen eingesetzt werden, wo eine intensive landwirtschaftliche Produktion, einschließlich der Viehzucht, nicht möglich ist.

Schlüsselwörter: *Fleckvieh, Polnische Schwarzbunte Rasse Milchleistung, Zellzahl, VCM, ECM, Kühe*

* West Pomeranian University of Technology, Department of Ruminant Science, Klemensa Janickiego 29, 71-270 Szczecin, Poland

** University of Life Sciences in Lublin, Institute of Animal Breeding and Biodiversity Conservation, Laboratory for Organic Production of Food of Animal Origin, Akademicka 13, 20-950 Lublin, Poland

Contact: ewa.janus@up.lublin.pl

1 Introduction

The main objective of cattle breeding is to obtain the greatest possible gain from cattle. In raising and breeding dairy cattle, particular attention should be paid to high milk yield during lactation and the number of times the cows gives birth in its lifetime (Litwińczuk et al., 2006). Through intensive breeding work and changes in housing systems imposing behavioural restrictions on the animals, a significant increase in productivity has been achieved in dairy cattle breeds (Sato and Kuroda, 1993; Dymnicki et al., 2003; Kuczaj, 2004; Strzałkowska et al., 2004; Guliński et al., 2005).

According to Mészáros et al. (2008), Zavadilová et al. (2009) and Zink et al. (2012) the health of the dairy cattle population and the length of productive life have deteriorated significantly due to intensification of production. The most common health problems in dairy herds involve the reproductive system and the udder. Udder health, affected by many factors, is indicated by the somatic cell count in the milk (Fadlelmoula et al., 2008; Borkowska et al., 2013). A change in its value also indicates deterioration of the chemical status of the milk (Koivula et al., 2005) and its suitability for processing (Górska, 2004; Le Maréchal et al., 2011). Somatic cells are a natural barrier protecting the udder (Janeway and Medzhitov, 2002; Ptak et al., 2011), and therefore an increase in the number of pathogenic microbes results in an elevated SCC in the milk (Harmon, 1994; Ødegârd et al., 2003; Danków et al., 2004), accompanied by a reduction in yield and a change in the chemical composition of the milk (Noori et al., 2013). Mastitis in dairy cattle is the cause of the largest share of veterinary treatment costs (Němcova et al., 2007) and one of the main causes of early culling (Varisella et al., 2007; Rzewuska et al., 2011).

According to Hagg et al. (2010), Dai et al. (2011) and Nantapo and Muchenje (2013), diet is one of the most important factors affecting the yield and the chemical composition of cow milk. Litwińczuk et al. (2006), Myburgh et al. (2012) and Ramatsoma et al. (2014) state that the quantitative and qualitative characteristics of milk are largely influenced by the individual properties of cows, their breed, and their genetic potential. Of all dairy breeds, the Black-and-White Holstein-Friesian variety has the highest genetically determined milk yield. For processing, however, the milk of this breed is less valued than that of the Simmental breed, which is characterized by lower yield but produces milk with a more favourable protein-to-fat ratio, which makes the milk more suitable for cheese production (Barłowska et al., 2009).

The aim of the study was to compare selected milk production traits of Simmental cows imported from the Czech Republic and born in Poland and Polish Black-and-White cows with up to 50 % Holstein-Friesian genes raised in the same environmental conditions.

2 Materials and Methods

The study was based on data collected on a farm in the village of Słońsk (52°33′46″N; 14°48′22″E), located in the Lubusz Voivodeship within the buffer zone of Ujście Warty National Park. On average, 133 cows were kept in the herd. These included 63 Simmental cows imported from the Czech Republic and their daughters born and raised in Poland (46 cows), as well as 24 cows of the Polish Black-and-White breed with up to 50 % HF genes (because of incomplete data on 3 of them, the study included 21 cows). The cows were kept in two free-stall barns on shallow litter. Their diet was based on complete compound feed (TMR system), which included maize silage, haylage, crushed oats, rapeseed meal and a mineral-vitamin blend. The cows were milked in a herringbone milking parlour (two rows of seven stalls) twice a day, and the milk was stored at 4°C in a DeLaval tank and collected every other day.

The data for the study came from breeding documentation kept on the farm and the results of use value assessment conducted on the farm and collected in the SYMLEK database. Data on the daily milk yield (in kg) of each cow and milk quality expressed as somatic cell count (SCC) in 1 ml of milk were taken from 12 consecutive monthly test-day milking results from a period of one year. Also collected were data on the milk, fat and protein yield, as well as the percentage content of these constituents in 305-day lactations completed in the year of the observations. For a reliable comparison of the yield of the cows, 305-day actual milk yield was converted to VCM (value corrected milk) and ECM (energy corrected milk). The corrected yields were calculated according to the following formulas:

$$VCM = -0.05 \times milk\ (kg) + 8.66 \times fat\ (kg) + 25.08 \times protein\ (kg)$$
(Arbel et al., 2001)

$$ECM = milk\ (kg) \times [0.383 \times fat\ (\%) + 0.242 \times protein\ (\%) + 783.2]/3.140$$
(Sjaunja et al., 1990).

Because the somatic cell count did not meet the conditions of normal distribution, its value was transformed to a natural logarithm (LnSCC) according to the formula given by Ali and Ahook (1980):

$$LnSCC = ln \times (SCC + 10)$$

The protein-to-fat and fat-to-protein ratios were calculated as well.

The experimental factors were as follows:

- breed and country of origin of cows, with three groups: CSIM – Simmental breed from the Czech Republic; SIM – Simmental breed born in Poland; ZB – Polish Black-and-White
- sampling period, with four periods: I – January-March, II – April-June, III – July-September, IV – October-December
- somatic cell count in 1 ml of milk, with four groups: SCC ≤ 100,000; 101,000–200,000, 201,000–400,000 and > 400,000.

Statistical analysis was performed in StatSoft Inc. STATISTICA ver. 7.1 software (2014). Features with a normal distribution were analysed using the following statistical model:

$$Y_{ij} = \mu + a_i + b_j + e_{ij}$$

where:

μ general mean
a_i effect of i-th breed and origin of cows
b_j *effect of j-th sampling period*
e_{ij} *random error*

The significance of the effect of the experimental factors on the features analysed was assessed by Duncan's tests for normal distribution and the X^2 test for qualitative features and features without normal distribution.

3 Results and Discussion

The data presented in Table 1 show that in each of the three-month periods the highest percentage of milk samples had a somatic cell count not exceeding 100,000/ml. The most such samples (53.46 %) were noted in the first period of the year (January-March); their frequency was much lower (about 40 %) in the third and fourth periods (July-September and October-December). Samples in which the SCC exceeded 400,000/ml were found in 14.41 to 24.68 % of cases, and were most common in October to December. The high percentage of milk samples with a somatic cell count of 200,000/ml or less indicates that milk was mainly obtained from cows in which the probability of mastitis was low. The sampling period was found to have a significant influence ($P \leq 0.01$) on milk quality. In the second half of the year (the 3rd and 4th periods), milk with a low (less than 200,000) somatic cell count was obtained from a smaller percentage of cows (63 % and 59 %) than in the first half (1st period – 71 % and 2nd period – 67 %).

In the period from January to March, Polish Black-and-White cows had a significantly increased SCC (over 400,000) in almost 30 % of milk samples. This may indicate an increase in the number of cases of subclinical mastitis in this breed. The percentage of milk samples with the highest SCC range increased in this group in successive sampling periods, up to a level of over 45 % in the period from October to December.

The data in Table 1 may indicate that udder health was best in the Simmental cows born in Poland (SIM), as from nearly 60 % to over 80 % of milk samples with SCC below 100,000 were recorded in cows in this group in individual periods. The milk of the other group of Simmental cows (CSIM), although this was the oldest group, also had a fairly low SCC; a high percentage of cows with a low somatic cell count (up to 200,000 in ml of milk) was noted in this group. The share of such samples in individual periods ranged from 52 % to 68 %. In both groups of Simmental cows, the milk sampling period was found to have a significant influence ($P \leq 0.01$); the later the sampling period, the lower the percentage of cows producing milk with a low SCC. It is difficult to conclusively state the reason for this. In all periods the breed and country of origin of the cows had a significant influence ($P \leq 0.01$) on the number of milk samples with a low SCC, and both groups of Simmental cows had more of them than the Black-and-White cows. However, the later the milk sampling period, the lower the value obtained in the X^2 test.

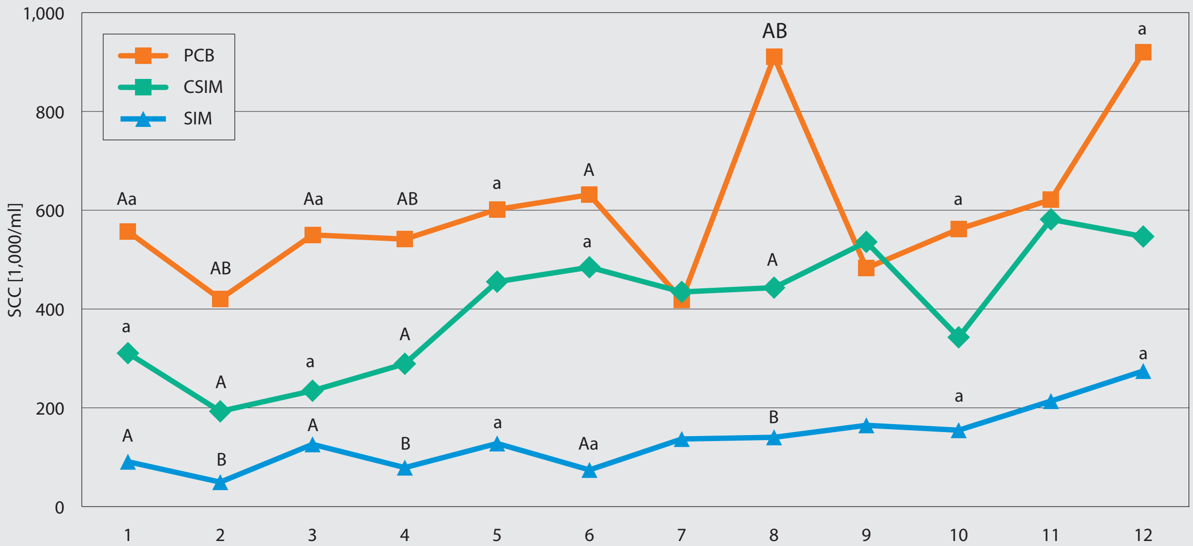
For comparison, Januś and Borkowska (2008) reported that the average somatic cell count in the Black-and-White cow breed was 757,000/ml. Gnyp et al. (2006a) obtained a somatic cell count range of 368,000 to 531,000/ml. According to Januś and Borkowska (2008), high temperatures may contribute to an increase in the SCC and thus in the number of cases of udder inflammation in the summer.

Table 1

Frequency of milk samples with a specified somatic cell count depending on the sampling period in each group of cows

Sampling period	SCC [1,000/ml]	CSIM $X^2 = 22.85$ *		SIM $X^2 = 22.10$ *		ZB $X^2 = 8.89^{NS}$		Total $X^2 = 26.00$ *	
		n	%	n	%	n	%	n	%
I $X^2 = 60.01$*	≤ 100	88	48.62	78	82.11	12	21.05	178	53.46
	101-200	36	19.89	9	9.47	14	24.56	59	17.72
	201-400	29	16.02	5	5.26	14	24.56	48	14.41
	> 400	28	15.47	3	3.16	17	29.83	48	14.41
	Total	181	100	95	100	57	100	333	100
II $X^2 = 60.63$*	≤ 100	71	42.52	79	73.83	9	17.31	159	48.77
	101-200	26	15.57	15	14.02	18	34.61	59	18.10
	201-400	21	12.57	9	8.41	7	13.46	37	11.35
	> 400	49	29.34	4	3.74	18	34.62	71	21.78
	Total	167	100	107	100	52	100	326	100
III $X^2 = 45.65$*	≤ 100	61	32.45	71	59.67	9	18.00	141	39.49
	101-200	45	23.93	28	23.53	12	24.00	85	23.81
	201-400	36	19.15	9	7.56	8	16.00	53	14.85
	> 400	46	24.47	11	9.24	21	42.00	78	21.85
	Total	188	100	119	100	50	100	357	100
IV $X^2 = 36.52$*	≤ 100	53	33.54	67	58.77	11	22.92	131	40.94
	101-200	30	18.99	22	19.30	7	14.58	59	18.44
	201-400	30	18.99	13	11.40	8	16.67	51	15.94
	> 400	45	28.48	12	10.53	22	45.83	79	24.68
	Total	158	100	114	100	48	100	320	100

* X^2 test value significant at $P \leq 0.01$; NS X^2 value not significant



Means with the same letters in different months of the year differ significantly: upper case letters – P ≤ 0.01; lower case letters – P ≤ 0.05

Figure 1
Mean SCC in the milk of cows of different breeds and countries of origin in each month of the year

The data presented in Figure 1 show that the milk of Black-and-White cows had significantly ($P \leq 0.01$ and $P \leq 0.05$) the highest mean SCC in nearly all months. Only in two months (August and October) did these cows have a slightly better result than the group of Czech Simmental cows. ZB cows had mean SCC values of 400,000/ml in only two months (February and July), while in the remaining months these values were about 500,000/ml or much higher.

In every month of the year, the most favourable SCC values were found for the Simmental cows born in Poland. In only two months (November and December) did this group produce milk with an average SCC content above 200,000/ml. In the remaining months, these values fluctuated around 100,000/ml or much lower. The other group of Simmental cows (from the Czech Republic), despite being the oldest group, also had relatively low SCC values. This suggests that Simmental cows have less serious problems with udder health than Black-and-White cows raised in the same conditions.

Table 2 shows that the average log-transformed somatic cell count ranged from 10.55 to 13.10. The highest value for this index (13.10) was found in December in the Black-and-White cows, and the lowest natural logarithm (10.55) was recorded in the Polish Simmentals in February. Similar LnSCC values, but in a narrower range (11.71-12.39), were obtained by Gnyp et al. (2006b). In a study by Borkowska and Januś

Table 2
Mean LnSCC values depending on the breed and country of origin of cows in each month of the year

Month	CSIM			SIM			ZB		
	n	x̄	SD	n	x̄	SD	n	x̄	SD
January	49	11.91 A	9.81	28	11.02 AB	7.99	20	12.40 B	9.90
February	57	11.55 A	9.82	30	10.55 AB	7.25	20	12.07 B	11.20
March	60	11.58	10.67	29	11.08 a	8.86	21	12.10 a	19.71
April	64	11.80 AB	10.12	35	10.99 BC	6.52	18	12.68 AC	8.60
May	60	11.95	11.83	36	11.34 A	7.42	16	12.52 A	10.08
June	59	12.14 A	11.72	38	10.90 AB	6.81	19	12.53 B	10.37
July	51	12.04 A	11.64	37	11.00 AB	10.21	19	12.22 B	10.59
August	65	12.12 AB	10.60	39	11.18 AC	9.11	19	13.05 BC	10.31
September	63	12.36 A	9.91	40	11.31 AB	9.37	19	12.42 B	9.57
October	60	11.96 a	9.92	37	11.10 Aa	16.10	14	12.49 A	10.21
November	65	12.46 A	10.31	37	11.42 AB	10.60	14	12.72 B	8.66
December	53	12.23 ab	10.49	46	11.36 Aa	11.76	17	13.10 Ab	9.78

Means in rows marked with the same letters differ significantly: upper case – at P ≤ 0.01; lower case – at P ≤ 0.05

(2010), the log-transformed somatic cell count in the Montbéliarde breed, depending on the factor analysed, was also in a smaller range (11.79-12.54). These authors' research indicated that the log-transformed somatic cell count was in part dependent on the season and the age of the cows. The influence of season of the year and lactation number were also reported by Fadlelmoula et al. (2008). These authors stated that SCC was lower in winter and spring season and higher in summer and autumn. These findings also indicated that SCC was higher in multiparous than in primiparous cows. According to Dürr et al. (2008), an increase in LnSCC by one unit can cause milk yield losses from 0.77 to 1.78 kg/day. Kocak (2006) estimated that daily milk losses due to mastitis range from 0.76 kg to 4.56 kg.

The LnSCC values calculated for Simmental cows of both groups in all months were found to be lower than in the Black-and-White cows. Bendelja et al. (2011) and Gottardo et al. (2017) also showed that Simmental cows had a more favourable log-transformed SCC than Holstein cows. In our research, the mean LnSCC in the milk of Polish Simmentals was significantly ($P \leq 0.01$ or $P \leq 0.05$) lower in each case than for the group of ZB cows. A similar relationship was also found for the SIM and CSIM cows, although for the months of March and May it was not statistically confirmed. It is likely that the higher LnSCC in the Czech Simmentals as compared to their daughters born in Poland was due to the fact that this was the oldest group of cows in the herd. It is also noteworthy that the average LnSCC values were within the narrowest range in the SIM cows (from 10.55 to 11.42). The values for this indicator were most varied in the ZB cows (12.07-13.10); the difference between the lowest and the highest values was 1.03. The LnSCC values reported by Sawa and Bogucki (2002) for Black-and-White cows with up to 50 % of Holstein-Friesian genes were lower and less varied (12.11-11.15) than those obtained in the present study.

The average 305-day milk yield in the groups of cows ranged from 5,690 to 6,388 kg (Table 3). Black-and-White cows had significantly higher ($P \leq 0.05$) milk yield, by almost 900 kg, than the Polish Simmentals. Compared to Czech Simmentals, however, the difference was less than 200 kg of milk. This relationship still held when actual yield was converted to ECM yield, although the differences between groups were smaller. However, when the actual milk yield was converted to VCM, the highest yield was found for the Czech Simmental cows. The groups did not differ significantly in terms of percentage content of fat in the milk (3.81-3.98 %); the lowest mean value for this feature was obtained for Czech Simmentals.

Milk protein content was significantly higher ($P \leq 0.01$) in both groups of Simmental cows than in the Black-and-White cows. As a result, both groups of Simmentals had significantly ($P \leq 0.01$) better ratios of fat to protein and protein to fat than the Polish Black-and-White cows. In a study by Fleszar (2009), the milk yield of Black-and-White cows in 305-day lactation was lower (4,150 kg) than that obtained in the present study, but the milk had more favourable fat (4.8 %) and protein (3.6 %) content. Polska Federacja Hodowców Bydła i Producentów Mleka (2018) reports that in 2017 Simmental cows kept in Poland surpassed Black-and-White cows in terms of milk yield (6,252 vs. 4,668 kg), and their milk contained more protein (3.45 % vs. 3.30 %), with comparable fat content (4.17 % vs. 4.16 %). Nistor et al. (2014), on the other hand, found that the Slovak Simmental population had lower milk yield (4,053 kg) and produced milk with lower protein content (3.12 %) than the Simmental cows in our research. In another study (Barłowska et al. 2009), the milk of Simmental cows had a higher content of fat and protein and a more favourable protein-to-fat ratio than Holstein-Friesian cows of the Black-and-White and Red-and-White varieties. Bendelja et al. (2011), in a comparison of the daily yield of cows of two breeds, found that Holstein cows produced significantly more milk with higher fat content, whereas the milk of Simmental cows had a higher protein content. Gottardo et al. (2017) compared four breeds and found that Holstein-Friesian cows achieved significantly the highest yield in comparison to the other breeds, including Simmental, but the milk of these cows had the lowest content of fat and protein. Skrzypek and Szukalski (2006), comparing the performance of domestic Black-and-White cows with that of imported ones, found lower milk yield in the Polish breeds, which produced 6,406 kg of milk in 305-day lactation, while the average yield

Table 3
Milk production traits of cows of different breeds and different countries of origin in 305-day lactation

Milk production traits	CSIM; n = 63		SIM; n = 46		ZB; n = 21	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Milk yield (kg)	6,388.50	1,194.20	5,690.10 [a]	1,123.50	6,573.90 [a]	1,614.80
VCM (kg)	7,752.14	1,554.43	7,222.45	1,334.87	7,456.65	2,011.40
ECM (kg)	6,194.24	1,016.55	5,616.98 [b]	1,032.82	6,400.24 [b]	1,508.85
Fat yield (kg)	242.06	41.77	224.28	41.62	246.24	82.89
Fat content (%)	3.81	0.47	3.93	0.38	3.98	0.32
Protein yield (kg)	208.48	48.62	195.14	38.04	195.41	63.70
Protein content (%)	3.38 [A]	0.22	3.39 [B]	0.21	3.14 [AB]	0.26
Fat/protein	1.12 [A]	0.09	1.16 [B]	0.09	1.28 [AB]	0.16
Protein/fat	0.89 [A]	0.08	0.87 [B]	0.07	0.79 [AB]	0.08

Means in rows marked with the same letters differ significantly: upper case – at $P \leq 0.01$; lower case – at $P \leq 0.05$

of the foreign breeds was 6,874 kg of milk. Czerniawska-Piątkowska and Szewczuk (2006) also reported lower yield in 305-day lactation for home-bred Holstein-Friesians in comparison to imported cows.

4 Conclusions

The research revealed significant variation in the somatic cell count in the milk of the cow population under study. The highest mean SCC and LnSCC were found in the milk of Black-and-White cows with Holstein-Friesian genes not exceeding 50 %, which may suggest that this breed is more susceptible to mastitis. The results for the Simmental breed were much more favourable in this regard. In cows of this breed born in Poland, the SCC in 58.77 to 82.11 % of milk samples did not exceed 100,000/ml. The Czech Simmentals, despite being the oldest group of cows, also produced a high percentage of samples with a low somatic cell count (up to 200,000 per ml of milk). The ZB cows had the highest actual and ECM milk yield in 305-day lactation, but VCM yield was highest in the Czech Simmentals. The milk of the Simmental cows also had a more favourable composition than that of the Black-and-White breed, as it contained significantly more protein. It also had more favourable proportions of the two most important milk constituents, i.e. fat and protein. The results suggest that Simmental cows can be successfully used on farms adjacent to areas under environmental protection, where intensive agricultural production, including livestock farming, is prohibited.

References

Ali AKA, Ahook CE (1980) An optimum transformation for somatic cell concentration in milk. J Dairy Sci 63(3):487-490

Arbel R, Bigun Y, Ezra R, Szturman H, Hojman D (2001) The effect of extended calving intervals in high-yielding lactating cows on milk production and profitability. J Dairy Sci 84(3):600-608

Barłowska J, Grodzicki T, Topyła B, Litwińczuk Z (2009) Physicochemical properties of milk fat from three breeds of cows during summer and winter feeding. Arch Tierz 52(4):356-363

Bendelja D, Prpić Z, Mikulec N, Ivkić Z, Havranek J, Antunac N (2011) Milk urea concentration in Holstein and Simmental cows. Mljekarstvo 61(1):45-55

Borkowska D, Januś E (2010) Analysis of the influence of chosen factors on somatic cell count in milk of Montbéliarde cows. Acta Sci Pol Zootech 9(4):39-46

Borkowska D, Januś E, Gajewska A (2013) Occurrence of mastitis in Polish Holstein-Friesian Black-and-White cows of different age and milk production capacity and its effect on the cytological quality of milk and the course of lactation. Acta Sci Pol Zootech 12(1):11-20

Czerniawska-Piątkowska E, Szewczuk M (2006) Comparison of milk yield and composition as well as age at first calving between home-bred heifer cows and those imported from Holland or Denmark. Acta Sci Pol Zootech 5(2):13-18

Dai XJ, Wang C, Zhu Q (2011) Milk performance of dairy cows supplemented with rapeseed oil, peanut oil and sunflower seed oil. Czech J Anim Sci 56(4):181-191

Danków R, Wójtowski J, Fahr R-D (2004) Hygienic quality of raw milk in relation to methods of production and storage. Med Weter 60(1):46-49

Dürr J, Cue RI, Monardes HG, Moro-Méndez J, Wade KM (2008) Milk losses associated with somatic cell country per breed, parity and stage of lactation in Canadian dairy cattle. Livest Sci 177(2-3):225-232

Dymnicki E, Krzyżewski J, Oprządek J, Reklewski Z, Oprządek A (2003) Relationship between the length of calving intervals and milk trace in Black-and-White cows. Med Weter 59(9):792-796

Fadlelmoula AA, Anacker G, Fahr RD, Swalve HH (2008) Factors affecting test-day somatic cell counts and milk yield of dairy cows . Int J Dairy Sci 3:105–111.

Fleszar J (2009) Quantitative and qualitative efficiency of milk production in ecological farm. J Res Appl Agric Engin 54(3):75-78

Gnyp J, Kowalski P, Tietze M (2006a) The influence of genotype and country of origin on 24-hour milk efficiency, milk composition and cytological quality in cows Ann U M C-S EE 24(1):1-8

Gnyp J, Kowalski P, Tietze M (2006b) Efficiency of the cow milk, its composition and cytological quality in relations to some environmental factors. Ann U M C-S EE 24(3):17-26

Górska A (2004) Yield and chemical composition of milk of cows with increased somatic cell count. Rocz Nauk Zootech-Supl 19:47-49

Gottardo P, Penasa M, Righi F, Lopez-Villalobos N, Cassandro M, De Marchi M (2017) Fatty acid composition of milk from Holstein-Friesian, Brown Swiss, Simmental and Alpine Grey cows predicted by mid-infrared spectroscopy. Ital J Anim Sci 16(3):380-389

Guliński P, Niedziałek G, Salamończyk E (2005) The course of milk production during lactation in cows depending on the length of the period to rearing peak milk production after calving and on the daily milk yield at lactation peak. Sci Ann Pol Soc Anim Prod 1(2):291-298

Hagg FM, Erasmus LJ, Henning PH, Coertze RJ (2010) The effect of a direct fed microbial (*Megasphaera elsdenii*) on the productivity and health of Holstein cows. S Afr J Anim Sci 40(2):101-112

Harmon RJ (1994) Physiology of mastitis and factors affecting somatic cell counts. J Dairy Sci 77(7):2103-2112

Janeway CA, Medzhitov R (2002) Innate immune recognition. Annu Rev Immunol 20:197-216

Januś E, Borkowska D (2008) The influence of selected factors on somatic cell count in milk of cows from freestall barns. Sci Ann Pol Soc Anim Prod 4(3):137-144

Kocak O (2006) Influence of mastitis on milk in Holstein cow. Acta Vet Brno 75:507-513

Koivula M, Mäntysaari EA, Negussie E, Serenius T (2005) Genetic and phenotypic relationships among milk yield and somatic cell count before and after clinical mastitis. J Dairy Sci 88(2):837-833

Kuczaj M (2004) Analysis of the usage value of Black-White cows imported from Holland and their Black- and Red-White contemporaries bred in Poland. Med Weter 60(12):1317-1319

Le Maréchal C, Thiéry R, Vautor E, Le Loir Y (2011) Mastitis impact on technological properties of milk and quality : a review. Dairy Sci Technol 91(3):247-282

Litwińczuk A, Barłowska J, Król J, Sawicka W (2006) Comparison of the chemical composition and urea content in milk of Black-White and Simental cows during the summer and winter feeding periods. Ann U M C-S EE 24(10):67-72

Mészáros G, Wolf J, Kadlečík O (2008) Factors affecting the functional length of productive life in Slovak Pinzgau cows. Czech J Anim Sci 53(3):91-97

Myburgh J, Osthoff G, Hugo A, de Wit M, Nel K, Fourie D (2012) Comparison of the milk composition of free-ranging indigenous African cattle breeds. S Afr J Anim Sci 42(1):1-14

Nantapo CTW, Muchenje V (2013) Winter and spring variation in daily milk yield and mineral composition of Jersey, Friesian cows and their crosses under a pasture-based dairy system. S Afr J Anim Sci 43(5):S17-S21

Němcova E, Štipkova M, Zavadilova L, Bouška J, Vacek M (2007) The relationship between somatic cell count, milk production and six linearly scored type traits in Holstein cows. Czech J Anim Sci 52(12):437-446

Nistor E, Bampidis VA, Pentea M (2014) Production traits of Romanian Simmental cows at first lactation. Slovak J Anim Sci 47(3):132-141

Noori R, Mahdavil AH, Edriss MA, Rahmani HR, Talebi M, Soltani-Ghombavani M (2013) Association of polymorphism in Exon 3 of toll-like receptor 4 gene with somatic cell score and milk production traits in Holstein dairy cows of Iran. S Afr J Anim Sci 43(4):493-498

Ødegârd J, Klementsdal G, Heringstad B (2003) Genetic improvement of mastitis resistance validation of somatic cell score and clinical mastitis as selection criteria. J Dairy Sci 86(12):4129-4136

Polska Federacja Hodowców Bydła i Producentów Mleka (2018) Rejestracja i rozmnażanie bydła mlecznego: dane za 2017 r [online]. To be found at <http://www.pfhb.pl/pages/show_pdf.html?attach_id=2598&f_name=Wyniki_Oceny_2017_www.pdf#book/3> [quoted 04.04.2018]

Ptak E, Jagusiak W, Żarnecki A, Otwinowska-Mindur A (2011) Heritabilities and genetic correlations of lactational and daily somatic cell score with conformation trans in Polish Holstein cattle. Czech J Anim Sci 56(5):205-211

Ramatsoma NI, Banga CB, MacNeil MD, Maiwashe A (2014) Evaluation of genetic trends for traits of economic importance in South African Holstein cattle. S Afr J Anim Sci 44(1):85-89

Rzewuska K, Jamrozik J, Żarnecki A, Strabel T (2011) Genetic parameters of test-day somatic cell scores for the first three lactations of Polish Holstein-Friesian cattle. Czech J Anim Sci 56(9):381-389

Sato S, Kuroda K (1993) Behavioural characteristics of artificially reared calves. Jpn J Zootech Sci 64(6):593-598

Sawa A, Bogucki M (2002) Genetic and environmental conditions of twenty-four hours milk yield and milk quality. Acta Sci Pol Zootech 1(1-2):129-138

Sjaunja LO, Baevre B, Junkkarinen L, Pedersen J, Setala J (1990) A nordic proposal for an energy corrected milk (ECM) formula [online]. To be found at <https://www.researchgate.net/publication/284193091_A_Nordic_proposal_for_an_energy_corrected_milk_ECM_formula> [quoted 26.09.2018]

Skrzypek R, Szukalski L (2006) Performance of Black-and-White cows imported from the Netherlands and Germany compared to cows bred in Poland. Med Weter 62(2):197-200

StatSoft (2014) STATISTICA ver. 7.1.

Strzałkowska N, Krzyżewski J, Reklewski Z, Dymnicki E (2004) Relationship between the strained length of calving intervals, some reproduction traits and adjusted cow's milk yield. Med Weter 60(12):1312-1316

Varisella E, Nienartowicz-Zdrojewska A, Dymarski I, Sobek Z (2007) Reasons for culling cows from ZZD IZ Pawłowice. Med Weter 63(8):975-978

Zavadilová L, Němcová E, Štípková M, Bouška J (2009) Relationships between longevity and conformation traits in Czech Fleckvieh cows. Czech J Anim Sci 54(9):385-394

Zink V, Lassen J, Štípková M (2012) Genetic parameters for female fertility and milk production traits in first-parity Czech Holstein cows. Czech J Anim Sci 57(3):108-114