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Quality of Primiparous Cow Milk In Automatic Milking System[1]

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Currently, various cow maintenance and milking systems are used in cattle breeding, affecting the udder and directly affecting its health condition. An early, accurate and stable udder health index is the number of somatic cells (SCC) in milk. It is the basic criterion determining the usefulness of milk for trade. SCC testifies to the milk cytological quality and, therefore, it can be an indicator used to assess the maintenance system and the impact of milking on the quality of milk. In particular, research on primiparous cows that have not experienced subsequent effects of an earlier type of use is reliable. It needs to be emphasised that the primiparous cows are a group defining the future milk production potential in the herd. Sun et al. (2010) report that after two years of investment, it should start earning money and should reimburse the costs of the maintenance.

Subclinical *mastitis* in the group of primiparous cows is considered an index of udder health and has a direct impact on the loss in milk production and the increase in the likelihood of *mastitis* as well as a deterioration of reproduction rates in subsequent years (de Vliegher, 2012). De Vliegher et al. (2004, 2005) underline the importance of elevated SCC levels at the beginning of the first lactation and its effect on the decrease in milk yield and the simultaneous increase in SCC throughout lactation. These authors add that the optimal level of SCC can be ≤50,000 of somatic cells in the first lactation - the breeder can count on healthier animals then, in which the udder inflammation occurs sporadically. As emphasised in the review work by Litwińczuk et al. (2015), there are unclear opinions of various authors regarding the effect of the automatic milking system (AMS) on the udder health. Berglund et al. (2002) indicate that the quality of milk from cowsheds equipped with AMS is at a similar level and sometimes better than in the case of a conventional milking system. The authors emphasise the better condition of quarters in a robotic milking system, which in their opinion is mainly the consequence of a greater frequency of milkings a day. According to Hovinen and Pyörälä (2011), irregularities in the detection of subclinical udder inflammation and inadequate hygienic conditions prevailing on a dairy cattle farms are the most common causes of *mastitis* in AMS cowsheds. The careful observation of animals and the knowledge of the interpretation of reports generated by AMS are very important because no robot can fully replace the human in this role nowadays.

The purpose of the study was to assess the efficiency and composition of milk and the number of somatic cells in the subsequent months of lactation of the primiparous cows milked in a cowshed equipped with the automatic milking systems.

Materials and methods

The research was carried out in a newly built barn located in the Kuyavian-Pomeranian Voivodship. The equipment of the barn with machines and equipment was characterised by a high technical level. It consisted of, among others, milking robots, robots skimming the feed and cleaning the slotted floor. The animals were kept in a free-stall cowshed in stool boxes made with straw. In the

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corridors there was a crevice floor. The IT system T4C with a high degree of innovation was used to manage the herd. The animal material consisted of 67 cows of the Holstein-Friesian breed milked in years 2014-2015. The animals were controlled in terms of milk yield, the percentage of fat and protein, and somatic cell count (SCC) in milk samples from trial milking sessions. When choosing animals for testing, it was assumed that the primiparous cow should be subjected to the control of milk yield at the latest within the first two months of lactation, and its lactation itself could not last shorter than 270 days. Another requirement was related to the number of milking cup samples - at least 4 of them. The total of 405 milk samples were analysed. For the purpose of statistical analysis, the number of somatic cells was transformed - the decimal logarithm (LOGSCC) was calculated.

Using the multivariate analysis of variance, the influence of the calving season and the lactation month of the primiparous cow on the yield, milk composition and logarithm of somatic cell count were examined. In the linear model of the analysis, in addition to the influence of the main factors, the interaction of the calving season × the lactation month was considered. The significance of the differences between the particular months of lactation in the scope of the aforementioned features was determined using the Scheffé multiple comparison test. Subsequently, in the course of the statistical proceedings, the milk samples were separated into the following classes due to the SCC content: ≤25, 26-50, 51-100, 101-200, 201-400, 401-800 and > 800 thousand in 1 ml. The statistical interdependence between the SCC class and the lactation month was examined using the independence test χ^2. Statistical calculations were made with SAS software (2014).

The results and their discussion

The analysis of variance showed a statistical effect of the lactation month on the milk yield in trial milkings and the content of protein and fat in it as well as the season of calving the primiparous cows for the protein content (Tab. 1). There was no statistical effect of the interaction of the above mentioned factors on the controlled characteristics of the milk yield. Due to the purpose of further work, a detailed analysis was made of statistics calculated in relation to the efficiency, composition and quality of milk divided by the months of lactation.

Table 1. Significance of the impact of main factors and interactions on milk composition and quality

Factor	*Milk (kg)*		*Protein (%)*		*Fat (%)*		LOGSCC	
	F	P	F	P	F	P	F	P
Month of lactation	11,22	<0,0001	28,81	<0,0001	8,71	<0,0001	1,15	0,3297
Calving season	3,19	0,0748	5,30	0,0218	3,51	0,0618	0,02	0,8817
Lactation month × Calving season	0,71	0,7016	0,67	0,7371	1,03	0,4149	1,18	0,3088

LOGSCC – Decimal logarithm of somatic cell count; F – Empirical value of statistics F; P – Probability.

The udder health is a low-inherited characteristics, but at the same time highly correlated with cow productivity, the use of antibiotics and the animal well-being (Antanaitis et al., 2015; Berry et al., 2004, de Vliegher et al., 2012; Dufour et al., 2011; Jacobs and Siegford, 2012, Mrode and Swanson, 2003, Santman-Berends et al., 2012, Sun et al., 2010). A healthy start to the first lactation is the key stage for the continued use of dairy cows (de Vliegher et al., 2012). In our own research, it was found that the average milk yield in the first month of lactation was 30.38 kg, and the peak of milkiness was reached in the second month - 34.57 kg (tab. 2). In the following months, the production decreased; however, until the sixth month it still remained above 30 kg (tab. 2, fig. 1). It was shown that cows finished their lactation by giving 24.09 kg of milk. There is no clear conclusion in the literature about the relationship between *mastitis* among the primiparous cows and their milk yield. In the studies of Antanaitis et al. (2015), it was found that the statistical signals for the detection of early mastitis may

be the decrease in the level of performance - such a relationship was observed in our own research. However, de Vliegher et al. (2012) conclude that this pattern is more common in herds characterised by higher milk production. In turn, Green et al. (2006), Hammer et al. (2012), Mollenhorst et al. (2011) and Schepers et al. (1997) reveal that low milk yield and the later stage of lactation increase the risk of *mastitis* in cows. In the work of de Vliegher et al. (2003) no relationship was found between the deterioration of teats and the milking system. At the same time, the authors emphasised that the group of cows was more sensitive and susceptible to trauma of the end of teats.

Table 2. Least squares means (LSM) of milk production traits in successive months

Lactation month	*Number of samples*	*Milk (kg)*	*Protein (%)*	*Fat (%)*	LOGSCC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE
1	36	$30{,}38\pm0{,}97^{a}$	$3{,}49\pm0{,}04^{Aa}$	$4{,}13\pm0{,}10$	$4{,}94\pm0{,}08$
2	58	$34{,}57\pm0{,}76^{Ab}$	$3{,}20\pm0{,}03^{AB}$	$3{,}76\pm0{,}07^{A}$	$4{,}81\pm0{,}06$
3	56	$33{,}41\pm0{,}76^{B}$	$3{,}26\pm0{,}03^{Cab}$	$3{,}78\pm0{,}08^{B}$	$4{,}75\pm0{,}06$
4	54	$31{,}66\pm0{,}80^{D}$	$3{,}36\pm0{,}04^{D}$	$3{,}83\pm0{,}08^{C}$	$4{,}74\pm0{,}06$
5	34	$30{,}74\pm1{,}00^{E}$	$3{,}52\pm0{,}04^{BEb}$	$3{,}95\pm0{,}10^{D}$	$4{,}69\pm0{,}08$
6	33	$30{,}74\pm1{,}01^{F}$	$3{,}49\pm0{,}04^{BFb}$	$3{,}89\pm0{,}10^{E}$	$4{,}72\pm0{,}08$
7	28	$28{,}71\pm1{,}09^{b}$	$3{,}56\pm0{,}05^{BCG}$	$3{,}83\pm0{,}11^{F}$	$4{,}79\pm0{,}08$
8	37	$29{,}45\pm0{,}96^{b}$	$3{,}66\pm0{,}04^{BCD}$	$4{,}12\pm0{,}09$	$4{,}87\pm0{,}07$
9	31	$27{,}18\pm1{,}05^{AB}$	$3{,}73\pm0{,}05^{BCD}$	$4{,}20\pm0{,}10$	$4{,}83\pm0{,}08$
10	38	$24{,}09\pm0{,}99^{ABDEFa}$	$3{,}88\pm0{,}04^{ABCDEFG}$	$4{,}64\pm0{,}10^{ABCDEF}$	$4{,}90\pm0{,}08$

A, B, C, D (a, b, c, d) – values in columns with the same capital (small) letters differ significantly at P≤0.01 (P≤0.05). SE – błąd standardowy, SE – standard error.

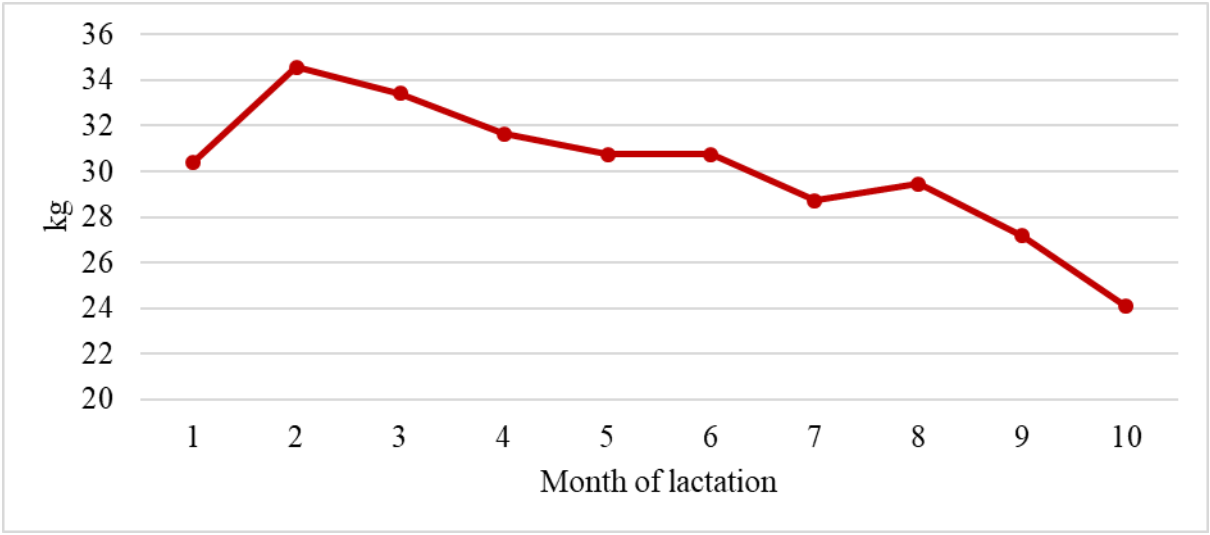

Fig. 1. Milk yield of primiparous cows in successive lactation months

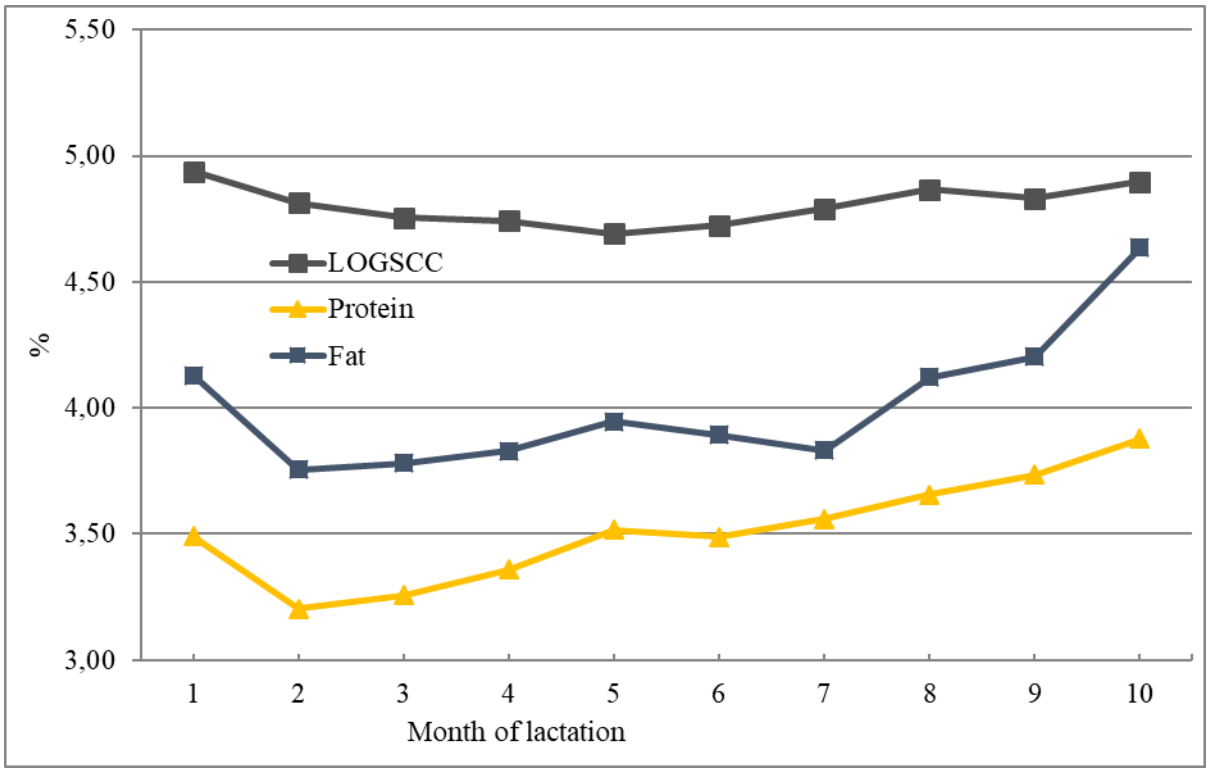

Fig. 2. Composition and quality of milk in successive lactation months

The analysis of the calculated least-squares means that the milk obtained from the primiparous cows was characterised by the highest content of protein (%) and fat (%) in the tenth month of lactation. The lowest level of milk composition was registered in the second month of lactation, respectively: protein - 3.20, fat - 3.76%. At the same time, it should be emphasised that the average protein content in the 2nd and 3rd month was 3.2% and more, which indicates a good supply of animals with energy (Ziemiński and Juszczak, 1997). In the subsequent months of lactation, the protein and fat content was systematically increasing. The protein content at the 8th, 9th and 10th month of lactation was over 3.6%, which indicates the over-feeding in terms of energy (Ziemiński and Juszczak, 1997). In month 10, as compared to month 2, the protein content increased by 0.68 and fat by 0.88 percentage points. Jakiel et al. (2011) showed in their research that with the increase in the daily content of somatic cells there is a decrease in the daily protein yield, and its content in milk grew to about 125 days of lactation. In our own research, this trend was not confirmed; both fat and protein content, after a decrease in the second month of lactation increased up to the 10th month after calving.

The analysis of the value of the decimal logarithm from the number of somatic cells showed that the primiparous cows had the highest value of this feature in the first month of lactation (tab. 2). In the following months of lactation a downward trend lasting up to month 5 was observed (fig. 2). Then, it changed to the growing trend, lasting until the final lactation phase. Lund et al. (1999) showed that the highest proportion of clinical *mastitis* cases occurred within the first 50 days of lactation. Very often *mastitis* is observed at the beginning of the first lactation although in the whole lactation it is usually lower than in multiparous cows. De Vliegher et al. (2005) found that already increased SCC content between the 5th and 14th day of the first lactation negatively affects the milk yield of cows and increases the risk of *mastitis* in the future. *Mastitis* among primiparous cows is a well known and widely discussed problem in the world (de Vliegher et al. (2005, 2012; Dufour et al., 2011, Santman-Berends et al., 2012). It is observed more often immediately after delivery, at the beginning of lactation and du-

ring the first 2-3 weeks of the dry period, which was confirmed by own research. This is a physiological phenomenon because colostrum does not rapidly change into milk. It is evidenced, inter alia, by a high percentage of protein (3.49%) in milk (Tab. 2). In turn, Mollenhorst et al. (2011) observed a very significant increase in SCC along with the milking day (especially above the 100th day of milking). The effect of milking day on SCC can be explained by its non-linear dependence on the milk yield (Schepers et al., 1997). In own research, conducted in the group of cows, this was not confirmed.

Table 3. Structure of milk samples depending on the SCC class and month of lactation

Somatic cell count (thous./dm^{-3})	*Month of lactation*									
	1	2	3	4	5	6	7	8	9	10
≤ 25	13,89	15,52	25,00	25,93	23,53	39,39	32,14	18,92	12,90	18,42
26–50	25,00	24,14	14,29	24,07	29,41	12,12	17,86	18,92	32,26	18,42
51–100	19,44	31,03	33,93	24,07	26,47	24,24	17,86	18,92	16,13	23,68
101–200	16,67	15,52	16,07	14,81	11,76	15,15	14,29	27,03	19,35	18,42
201–400	13,89	10,34	8,93	5,56	8,82	6,06	14,29	13,51	12,90	18,42
401–800	2,78	1,72	0,00	3,70	0,00	0,00	0,00	0,00	0,00	0,00
> 800	8,33	1,72	1,79	1,85	0,00	3,03	3,57	2,70	6,45	2,63
$\chi^2 = 45{,}244$; $P_{\chi^2} = 0{,}796$										

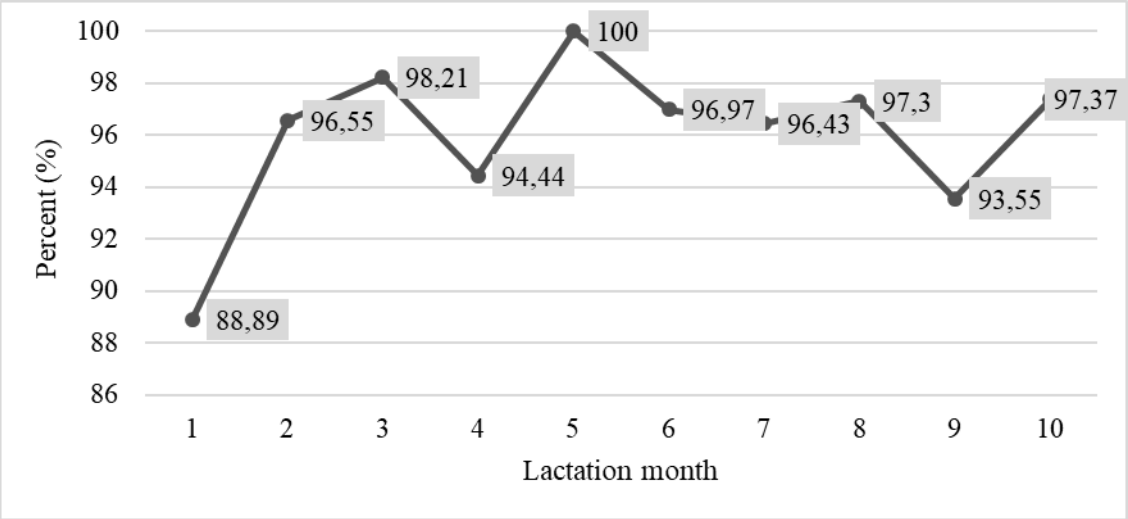

Fig. 3. The percentage of milk samples with up to 400,000 somatic cell count

As expected, a statistical analysis of the interdependence between the month of lactation and the number of somatic cells, carried out with the independence test χ^2, confirmed the results of the analysis of variance, i.e. the lack of significance of the impact of the lactation month on the natural logarithm of the number of somatic cells (Tab. 3). Due to the SCC class, it was observed that the poorest cytological quality of the milk of primiparous cows was in the first month of lactation - 11.11% of milk samples contained over 400,000 somatic cells (Figure 3). In the subsequent months of lactation, the share of these samples did not exceed 7%, thus maintaining a similar level. It should be emphasised that from the 2nd to the 9th month of lactation the share of milk samples with the number of cells up to 200,000 exceeded 80% (tab. 3), and that in the 5th month of lactation no samples from SCC exceeding 400,000 were found. (Tab. 3, fig. 3). As emphasised by Dohmen et al. (2010), udder hygiene on farms with AMS has a high impact on the SCC levels in milk. According to these authors, poor hygiene can lead to more *mastitis* cases than the traditional milking system. In the analysed herd, the percentage of samples with increased somatic cell content was very low, which proves the good hygienic conditions in the cowshed. Some researchers indicate that the use of AMS on a farm causes an increase in inflammation of udders and subclinical *mastitis* among primiparous cows (Hovinen and Pyörälä, 2011, Santman-Berends et al., 2012). This may be related to the hierarchy in the herd, the wrong number of cows per robot, and the need to adapt the primiparous cows to AMS. Jacobs and Siegford (2012) emphasise that if a breeder wants to have a healthy and highly productive herd, then in cowsheds equipped with AMS the effect of social dependencies and interactions between animals is very important and should always be taken into account. De Vliegher et al. (2012) add that milking machines are most often optimised for multiparous cows, which is not necessarily optimal for primiparous cows whose udders differ in size and shape from cows in subsequent lactations. In the studies of Nogalski et al. (2011) primiparous cows with healthy udders (SCC < 200 thousand) accounted for about 75%, in the own research between the 2nd and the 9th month of lactation a group of such animals exceeded 80%. Olechnowicz et al. (2006) emphasise that the health of the udder is positively influenced, first and foremost, by the possibility of very early detection of *mastitis* and the prevention of empty milkings of the front udder quarters, which are milked shorter. Hovinen and Pyörälä (2011), Pyörälä (2003) and Hogeveen et al. (2010) prove that in the case of cowsheds equipped with AMS, careful observation of animals, the analysis of indicators from the herd management system and the knowledge of the use of measurements made by the robots give a good chance to improve the hygienic quality of milk.

Summary and conclusions

In the summary of the results of the conducted research it should be stated that the milked primiparous cows in the barn equipped with AMS presented a high level of milk production and its favourable composition for the prevailing part of lactation. In addition, it was shown that the primiparous cows' milk was characterised by a good cytological quality. Both facts prove the beneficial effects of the automatic milking systems on the milk yield in lactation and the cytological quality of milk.

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QUALITY OF PRIMIPAROUS COW MILK IN AUTOMATIC MILKING SYSTEM

Summary

The purpose of the study was to assess the milk yield and composition as well as the number of somatic cells in subsequent lactation months of primiparous cows in a shed equipped with an automatic milking system. The animal material were 67 Holstein-Friesian primiparous cows milked in the years 2014–2015. A total of 405 milk samples from animals included in the study were analysed. For the purposes of statistical analysis, the number of somatic cells has been transformed and a decimal logarithm has been calculated. The statistical analysis of collected figures was carried out using a two-factor variance analysis and an χ^2 independence test. Both statistical methods applied showed a highly significant or significant impact of the month of lactation on milk yield and composition, and an insignificant impact on the number of somatic cells. The lowest cytological quality of milk was observed in the first month of lactation – 11.11% of milk samples contained more than 400,000 somatic cells per ml. From the second to the ninth month of lactation, the share of milk samples with up to 200,000 cells exceeded 80%. In the fifth month of lactation, no samples with somatic cells exceeding 400,000 were detected. In summary, it has been proven that animals included in the study showed a high level of milk production, a favourable milk composition and good cytological quality for a far longer part of the lactation period, which may be the result of the automatic milking system used.

Key words: primiparous cow, milk yield, somatic cell count, automatic milking system