

## THE COMPARISON OF YIELD, COMPOSITION AND QUALITY OF COW MILK DEPENDING ON TWICE-A-DAY AND FOUR-TIMES-A-DAY MILKING

Ewa Czerniawska-Piątkowska, Katarzyna Gralla, Małgorzata Szewczuk,  
Ewa Chociłowicz

West Pomeranian University of Technology, Szczecin, Poland

**Abstract.** The aim of this study was the comparison of yield, composition and quality of cow milk depending on twice-a-day and four-times-a-day milking. The research was performed on Polish Holstein-Friesian cows of Black-and-White. It was found that milking frequency affected milk yield and composition. A higher daily milk yield was observed in winter, spring and summer for the four-times-a-day milking. Significant differences ( $P \leq 0.01$ ) were recorded in spring and summer. Somatic cell count in milk was found to be the highest in autumn in both compared groups. The differences between groups were significant ( $P \leq 0.01$ ). It is still necessary to have a real improvement quality of milk by following the appropriate procedures for its acquisition thereby enable the production of high-quality material.

**Key words:** cows, milk composition, milking frequency, milk yield, somatic cell count

### INTRODUCTION

An increase in the yield of milk obtained from a cow and in the content of its basic constituents is of great economic significance. A higher yield and improved quality of milk could compensate for the decreasing number of cows and the lower amount of purchased milk in Poland. Węglarzy et al. [2009] consider that the milk yield of cows depends on many factors, among other things, genetic potential, nutrition, gestation and the length of calving interval, herd structure, management

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Corresponding author – Adres do korespondencji: dr hab. inż. Ewa Czerniawska-Piątkowska, West Pomeranian University of Technology, Szczecin, Department of Ruminant Science, Doktora Judydy 10, 71-460 Szczecin, Poland, e-mail: Ewa.Czerniawska-Piatkowska@zut.edu.pl

conditions, health and milking frequency. An increased milking frequency positively affects lactation in cows, stimulation of the udder increases the proliferation of mammary gland cells and decreases their apoptosis. A larger number of milkings improves milk quality and udder health due to the frequent emptying of the mammary gland. The amount of bacteria and the time of their presence in the teat canal also decrease, which influences the reduced susceptibility to mastitis [Bogucki et al. 2009, 2011].

The aim of this study was the comparison of yield, composition and quality of cow milk depending on the twice-a-day and four-times-a-day milking.

## MATERIAL AND METHODS

The study was conducted on 298 Holstein-Friesian dairy cows of Black-and-White strain for 2009–2011 years. The cows were divided into 2 groups according to the number of milkings: the group of cows milked twice a day (92 individuals) and the group of cows milked four times a day (206 individuals). The quality of milk based on somatic cell count in milk was analyzed for the period from January to December 2010, taking into account the time of year. The animals were fed and managed under the same environmental conditions. The cows were kept in free-stall barns. To maintain appropriate microclimatic conditions, fans, curtains and artificial lighting for supplementing natural light had been installed in the barns. Livestock buildings were also fitted with insulated and T80 waterers as well as active and pneumatic cow brushes. The animals were fed complete TMR diets according to their level of milk production. To fully satisfy the requirements of animals for microelements, the salt blocks with microelements and vitamins were used. Feed ration contained the following feeds: maize silage, CCM maize, dried sugar beet pulp, wet sugar beet pulp silage, alfalfa silage, haylage, straw, soy and rape extracted meal, triticale meal. The diet was supplemented with the following feed additives: forage chalk, sodium bicarbonate, protected fat as well as vitamin and mineral concentrates.

Milking was performed in a side-by-side 2×8 milking parlor fitted with the DeLaval® equipment. In the four-times-a-day milking animals were milked at 6-hour intervals: 4.00, 10.00, 16.00 and 22.00. The twice-a-day milking was performed every 12 hours: at 5.30 and 17.00.

The following milk performance traits were derived from the database of the SYMLEK system: milk yield (kg), milk protein and fat yield (kg), milk protein and fat content (%) and the somatic cell count in milk. The results of the five consecutive 305-day lactations were analyzed. Somatic cell count (SCC) expres-

sed in thousands per  $\text{ml}^{-1}$  was transformed into natural logarithm (LnSCC) using Excel®, which made it possible to obtain the normal distribution of this trait. The mean ( $\bar{x}$ ), standard deviation (S) were calculated and the one-way analysis of variance was performed using the Duncan's multiple range test for the comparison between selected traits. All statistical calculations were done by means of Statistica 10 PL software.

## RESULTS AND DISCUSSION

The comparison of milk yield and composition depending on the twice-a-day and four-times-a-day milking with regard to 305-day lactations is presented in Table 1.

Table 1. Milk yield and composition of milk depending on frequency of milking of 305-days lactation

Tabela 1. Wydajności i skład mleka w zależności od częstotliwości doju za laktacje 305-dniowe

Trait Cecha	Milk, kg Mleko, kg		Fat, kg Tłuszcz, kg		Fat, % Tłuszcz, %		Protein, kg Białko, kg		Protein, % Białko, %		
	2-time 2-krotny	4-time 4-krotny	2-time 2-krotny	4-time 4-krotny	2-time 2-krotny	4-time 4-krotny	2-time 2-krotny	4-time 4-krotny	2-time 2-krotny	4-time 4-krotny	
Lactation Laktacja	n	26	56	26	56	26	56	26	56	26	56
I	$\bar{x}$	8 457	8 737	334.00	325.23	3.97	3.75	285.15	289.00	3.38	3.33
	SD	941	1366	38.55	51.39	0.47	0.46	32.84	36.47	0.15	0.20
II	n	26	57	26	57	26	57	26	57	26	57
	$\bar{x}$	9 810**	10 922**	404.5	410.11	4.18**	3.79**	335.23*	360.18*	3.43*	3.32*
	SD	1702	1692	55.55	57.17	0.61	0.47	52.78	44.94	0.17	0.19
III	n	27	48	27	48	27	48	27	48	27	48
	$\bar{x}$	10 531**	12 092**	415.41	440.98	3.93	3.67	356.74**	392.08**	3.39**	3.26**
	SD	1 526	1 657	91.35	67.44	0.56	0.54	52.02	45.17	0.18	0.20
IV	n	10	29	10	29	10	29	10	29	10	29
	$\bar{x}$	13 715	12 537	594.00	456.17	5.37	3.70	446.00*	407.41*	3.72	3.28
	SD	1 689	2 309	73.78	78.41	0.64	0.61	49.85	58.98	0.17	0.26
V	n	3	12	3	12	3	12	3	12	3	12
	$\bar{x}$	13 599	12 484	574.00	454.33	4.64	3.64	473.00	395.42	3.50	3.18
	SD	2343	1279	112.76	84.34	0.46	0.58	96.21	33.21	0.17	0.21
I-V	n	92	206	92	206	92	206	92	206	92	206
	$\bar{x}$	9 827**	10 987**	392.92	405.50	4.02**	3.73**	332.66**	358.96**	3.39**	3.29**
	SD	1746	2227	77.71	80.45	0.56	0.51	57.96	62.89	0.17	0.21

\*\* – statistically significant differences at  $P \leq 0.01$ ; \*\* – różnica istotna na poziomie  $P \leq 0,01$

\* – statistically differences at  $P \leq 0.05$ ; \* – różnica istotna na poziomie  $P \leq 0,05$

A statistically significant effect of the milking frequency on the analyzed 305-day lactations was found. A statistically significantly high ( $P \leq 0.01$ ) yield was observed in the four-times-a-day milking group in the second (11.34%) and third (12.91%) lactations as well as all the studied lactations (I–V) compared with a twice-a-day milking group. Low milk yield were observed in the four-times-a-day

milking group in the fifth lactation. The individuals from the first three lactations (I–III) should be selected to the group of an increased milking frequency since a decreased yield and shorter liveability resulting from utilization are observed in subsequent lactations, which leads to the culling of cows [Borkowska and Januś 2006]. In the study by Dorynek et al. [2006], the cows in the second lactation were culled most frequently. Wangler [2009] conducting research on German Holstein-Friesian cows observed that the animals were eliminated from the herd due to the low yield already in the middle of the third lactation.

An advantageous effect of an increased milking frequency on the higher milk yield has been observed by other authors as well [Wołkowi et al. 2003, Gnyp et al. 2006, Bogucki et al. 2009, Kaczor and Paschma 2009, Węglarzy et al. 2009, Bogucki et al. 2011]. Wołkowski et al. [2003] emphasized that an increased milking frequency results in the improvement of the mammary gland physiology. Ziemiński and Makowska [1998] also observed an increase in milk yield in the subsequent lactations in the group with a higher milking frequency; however, in the fourth and subsequent lactations the difference between individual milkings becomes clearly smaller. Wołkowski et al. [2003] consider that the introduction of the higher milking frequency to the group of cows in later lactations is justified despite the lower milk yield, since a more frequent milking improves milk quality, which is also important for its acquisition.

An increased milking frequency significantly affects the technological value of milk for processing, since the milk lying in the mammary gland between milkings has a temperature of approx. 38.5°C and this is the optimum temperature for the occurrence of the proteolysis processes, in which the milk plasma constituents are involved. When the milk remains shorter in the mammary gland, there is less time for the casein degradation and milk fat lipolysis, which improves the technological quality of milk, among other things, for cheese production [Wołkowski et al. 2003].

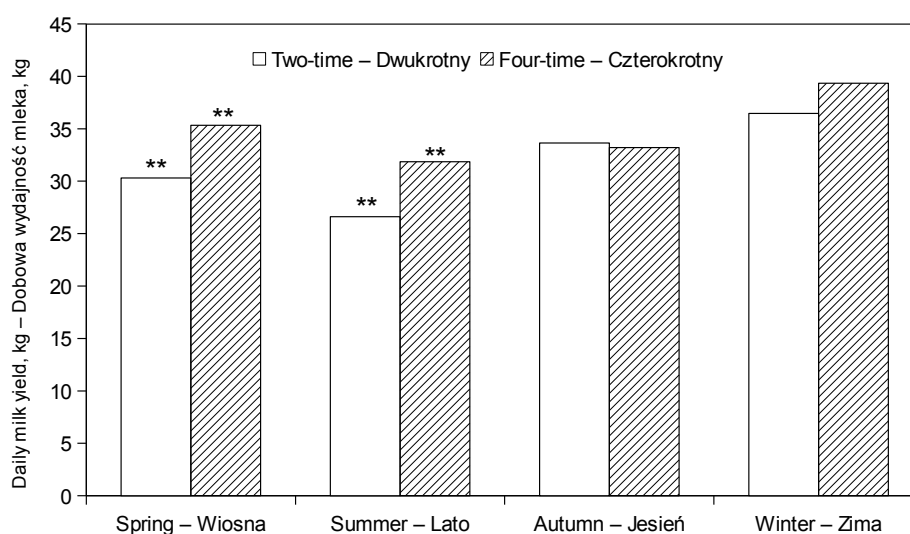
On the other hand, Sawa and Bogucki [2002] and Wołkowski et al. [2003] consider that an increased milk yield with a more frequent milking advantageously affect milk constituents i.e. fat and protein. According to Sawa and Bogucki [2002] it is caused by a better selection of animals, greater professionalism of the zootechnical and veterinary staff, more rational feeding, which is associated with a high production level of a herd.

Gnyp et al. [2006] recorded an increase in the milk fat content in the three subsequent analyzed lactations and an increase in protein content until the second lactation. In subsequent lactations, the authors observed a clear decrease in the milk fat and protein parameters. Litwińczuk et al. [2006] made similar observations on the milk fat content. At the same time, they found a difference in the

increase in milk protein content until the third lactation. Other investigators [Węglarzy et al. 2009, Bogucki et al. 2011] did not find any effect of milking frequency on milk composition.

When analyzing milk protein yield depending on the twice-a-day and four-times-a-day milking, significant differences were recorded in the second ( $P \leq 0.05$ ) and third ( $P \leq 0.01$ ) lactations as well as in all the analyzed lactations (I–V) ( $P \leq 0.01$ ) for the four-times-a-day milking. On the other hand, milk fat yield was significantly higher in the second lactation ( $P \leq 0.01$ ) and in all the analyzed lactations (I–V) ( $P \leq 0.01$ ) in the four-times-a-day milking group.

A significantly higher ( $P \leq 0.01$ ) daily milk yield for the four-times-a-day milking was observed in autumn (14.18%) and summer (19.55%) months compared with the twice-a-day milking (Fig. 1). Lower daily productivity was recorded in summer in comparison with the winter season for the four-times-a-day milking. Stenzel et al. [2001] observed a higher yield in summer than in winter. Gnyp et al. [2006] found the highest daily milk yields in spring and winter, whereas Stanek et al. [2004] observed the highest productivity in the autumn-winter period and the lowest one in summer, which was confirmed in the present study (Fig. 1).



\*\* – statistically significant differences at  $P \leq 0.01$ ; \*\* – różnice istotne na poziomie  $P \leq 0,01$

Fig. 1. Comparison daily milk yield depending on frequency of milking in consideration of season

Rys. 1. Porównanie dobowej wydajności mleka w zależności od częstotliwości doju z uwzględnieniem pory roku

An increased somatic cell count is a response of the immune system to the invasion of the udder by pathogenic bacteria. An increased somatic cell level results in reduced production, the alteration of the biochemical composition and deterioration in the milk quality, which consequently leads to the serious economic loss by a breeder. Milk with an increased level of somatic cell count has smaller technological usefulness and lower dietary value. The content of the substances dangerous for the human health increases in the milk of cows suffering from mastitis. It is important to obey appropriate sanitary and hygienic rules during milk acquisition [Jakiel et al. 2011].

It was found that the critical season is autumn, since the somatic cell count (SCC) was the highest then both in the cows milked twice and four times a day (Table 2). This has been confirmed by other authors as well [Stanek et al. 2004, Gnypl et al. 2006]. It could have been caused by an additional stress e.g. hoof correction, changeable atmospheric conditions e.g. rain, relatively large temperature amplitudes, overlapping atmospheric fronts, which results in pressure changes, wind etc. All the above-mentioned factors result in reduced immunity of animals, higher susceptibility to infections, mastitis and thus a reduced milk yield [Arvidson et al. 2005].

Table 2. Comparison of somatic cell count in daily milk yield depending on frequency of milking in consideration of season

Tabela 2. Porównanie liczby komórek somatycznych w dobowej wydajności mleka w zależności od częstotliwości doju z uwzględnieniem pory roku

Milking Dój	N	Statistic Statystyka	Winter – Zima		Spring – Wiosna		Summer – Lato		Autumn – Jesień	
			LSCC LnLKS	SCC '000/ml LKS tys./ml	LSCC LnLKS	SCC '000/ml LKS tys./ml	LSCC LnLKS	SCC '000/ml LKS tys./ml	LSCC LnLKS	SCC '000/ml LKS tys./ml
2-time 2-krotny	29	$\bar{x}$ SD	11.29 1.45	256 461	11.33 1.25	212 365	11.57 1.14	209 299	12.13 1.35	754** 2563
4-time 4-krotny	64	$\bar{x}$ SD	11.50 1.27	295 700	11.44 1.31	289 657	11.79 1.26	352 752	12.04 1.28	400** 638

Other authors [Malinowski 2001, Stenzel et al. 2001, Sawa and Bogucki 2002], recorded a higher SCC in summer. According to Malinowski [2001] and Stenzel et al. [2001] it results from greater susceptibility to mastitis caused by microorganisms developing under the conditions of high humidity and temperature as well as by stress associated with a high temperature in summer.

Grodzki et al. [1998] observed a higher somatic cell count in milk in winter rather than in summer, explaining this in terms of better management of cattle on pastures in summer than in barns in winter. Different opinion has been expressed

by Januś and Borkowska [2008] who consider that the staying of cattle on pasture can affect improved cytological quality of milk due to the green fodder consumed by animals.

Januś and Borkowska [2008] and Jakiel et al. [2011] found an increase in somatic cell count in milk with a simultaneous drop in milk yield, which was not confirmed in the present study (Table 2). Stenzel et al. [2001] found an opposite relationship. Sewalem et al. [2010] explains this situation by the fact that the high yielding cows are usually characterized by a greater speed of milk ejection. The teat canal diameter in these cows is relatively large. The larger the teat canal diameter is, the less elastic the muscles closing it are and the higher the susceptibility to infections is. Przysucha et al. [2004] consider that on the farms with a high milk yield of cows the care of milking hygiene and thus the health state of cows' udders is better and so the somatic cell count in the milk from these cows is lower. Węglarzy et al. [2009] emphasize the fact that the frequent emptying of the udder results in the lower somatic cell count in milk. According to Borkowska and Januś [2010], the high yielding animals are more susceptible to acute mastitis but also characterized by high cytological quality of milk.

## **CONCLUSIONS**

Milking frequency affected milk yield and composition. In the first three lactations, the highest milk and protein yields were found in cows milked four times a day. The differences were significant ( $P \leq 0.01$ ,  $P \leq 0.05$ ). A higher daily milk yield in cows was shown in winter, spring and summer for the four-times-a-day milking. Significant differences ( $P \leq 0.01$ ) were found in spring and summer. The analysis of the somatic cell count in milk revealed that it was the highest in autumn in both compared groups. It is still necessary to have a real improvement quality of milk by following the appropriate procedures for its acquisition thereby enable the production of high-quality material.

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## **WYDAJNOŚĆ, SKŁAD I JAKOŚĆ MLEKA KRÓW W ZALEŻNOŚCI OD CZĘSTOTLIWOŚCI DOJU**

**Streszczenie.** Celem pracy było porównanie wydajności, składu i jakości mleka krów w zależności od częstotliwości doju. Badania przeprowadzono na krowach rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej. Stwierdzono, że częstotliwość doju miała wpływ na wydajność i skład mleka. Wykazano przewagę wydajności dobowej krów w sezonie zimowym, wiosennym oraz letnim przy doju czterokrotnym.

Różnice istotne ( $P \leq 0,01$ ) stwierdzono w okresie wiosny i lata. Analizując liczbę komórek somatycznych mleka, stwierdzono, że była ona najwyższa w sezonie jesiennym w obu porównywanych grupach. Różnice pomiędzy grupami były istotne ( $P \leq 0,01$ ). Ciągłe jeszcze istnieje konieczność poprawy jakości mleka poprzez przestrzeganie odpowiednich procedur związanych z jego pozyskiwaniem, co tym samym pozwoli na produkcję surowca najwyższej jakości.

**Słowa kluczowe:** częstotliwość doju, krowy, liczba komórek somatycznych, skład mleka, wydajność mleka

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