ORIGINAL PAPER

ANALYSIS OF THE MILK YIELD AND MILKING FREQUENCY OF POLISH BLACK-AND-WHITE HOLSTEIN-FRIESIAN COWS HOUSED IN A BARN WITH AN AUTOMATIC MILKING SYSTEM (AMS)

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ABSTRACT

The aim of the study was to analyse milk yield and the frequency of use of a milking robot by Polish Holstein-Friesian cows. The study was carried out on a farm where a double-stall Astronaut milking robot from Lely was installed in a free-stall slatted-floor barn for 120 cows. The material for the study was obtained from the herd management system and comprised 850 milking records. Daily milk yield (in kg), number of milking sessions per day, and average milk yield per milking were analysed. The experimental factors were lactation number (primiparous and multiparous cows), daily milk yield (≤15 kg, 15.1–25.0 and >25.0 kg) and stage of lactation (≤100 days, 101––200 days and >200 days). The cows in the herd were found to use the milking robot with an average frequency of 2.49 times a day. No significant differences were noted in daily yield or frequency of milking between primiparous and older cows. They also did not differ significantly in terms of milk yield per milking. The level of daily yield influenced the milking frequency. Use of the milking robot was most frequent among primiparous and multiparous cows with daily yield of more than 25.0 kg of milk (2.82 and 2.67 times per day, respectively). In the case of both primiparous and multiparous cows, an increase in daily milking frequency was accompanied by an increase in the amount of milk obtained per milking. In the group of primiparous cows, the daily milking frequency increased in the three successive stages of lactation. Increased milking frequency was also found to be linked to a decrease in the amount of milk obtained in one milking. In the multiparous cows, the daily milk yield and quantity of milk per milking decreased systematically in successive stages of lactation, while the daily milking frequency varied irregularly.

Key words: Polish Holstein-Friesian breed, automatic milking system, primiparous, multiparous, milking frequency, daily milk yield, lactation stage

INTRODUCTION

Breeders of dairy cows improve and select them for milk yield and strive to achieve the best possible economic results using the least possible means of production. Science and technology help by offering a number of new solutions aimed at saving time and labour and minimizing the human factor in the milk production process [Hansen 2015].

The work of engineers has resulted in the automatic milking system (AMS), or milking robot, which eliminates the need for people to milk cows in the barn. This system is increasingly installed in large cow barns, despite the significant costs of installation and operation [Brouček and Tongel' 2015, Hansen 2015]. Cows can use the milking station whenever and as often as they choose, and additional labour costs for milking are avoided [Hogeveen et al. 2004]. Løvendahl and Chagunda [2011] reported that about 20% more milk was obtained from cows milked more frequently than from cows with the lowest daily milking frequency. Bogucki et al. [2009] and Węglarzy et al. [2009] have also shown an increase in milk yield as a result of increased milking frequency. A study conducted in New Zealand [Clark et al. 2006] showed that the yield of cows milked once a day was 31.2% lower in the case of Holstein-Friesians and 22.1% lower for Jersey cows as compared to cows milked twice a day.

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The positive effect of increased milking frequency on milk yield can be explained by increased proliferation of milk-producing cells [Capuco 2003, Hale et al. 2003] and more frequent removal of proteins inhibiting milk production, such as FIL (Feedback Inhibitor of Lactation) or serotonin [Wilde et al. 1995, Collier et al. 2012]. Pettersson et al. [2011] found that the effect of more frequent milking on the amount of milk obtained was more pronounced during early lactation and was less evident as lactation progressed. Hale et al. [2003], however, found that the increase in milk yield resulting from increased milking frequency (from two to four times a day) during the first three weeks after calving was apparent not only during this period but after it as well.

The aim of the study was to analyse the milk yield of Polish Holstein-Friesian cows and the frequency with which they use a milking robot.

MATERIAL AND METHODS

The material for the study consisted of data obtained from the Lely herd management system using the Astronaut two-stall milking robot. The automatic milking system (AMS) was installed in a free-stall barn with a slatted floor, housing 120 dairy cows of the Polish Black-and-White Holstein-Friesian breed. Depending on their physiological period and daily yield, the cows were divided into two feeding groups and given TMR rations adjusted to their nutritional needs.

The study included data from 850 milking sessions recorded in the system over a period of three consecutive days. The data included daily milk yield (in kg), number of milking sessions per day, and average milk yield per milking, and the experimental factors were lactation number (primiparous and multiparous cows), daily milk yield (≤15 kg, 15.1–25.0 and >25.0 kg) and stage of lactation (≤100 days, 101–200 and >200 days).

Statistical analysis of the results was performed using StatSoft Inc. STATISTICA software ver. 9.0 [2010]. Standard statistical measures (mean and SD) were used. The significance of differences between means was determined by Duncan's test at significance levels of P ≤ 0.01 and P ≤ 0.05.

RESULTS AND DISCUSSION

The data in Table 1 show that the cows in the herd used the milking robot with an average frequency of 2.49 times per day. Their daily yield was 24.23 kg, and during one milking they produced on average 9.91 kg of milk. The statistical analysis showed no significant differences in daily yield and milking frequency between primiparous and older cows. They also did not differ significantly in terms of milk yield per milking session. The daily yield of multiparous cows was only 3.09 kg higher (26.66 kg) than that of primiparous cows (23.57 kg), and the frequency of use of the milking robot by these two groups of cows was similar (2.50 vs. 2.49). Pettersson et al. [2011] reported no differences in the milking frequency of primiparous and multiparous cows in early lactation, but found that in the later period it decreased much more in multiparous cows than in primiparous cows. Speroni et al. [2006] reported marked differences in AMS milking frequency between primiparous and multiparous cows. In that study primiparous cows used the milking robot 2.8 times a day, while older cows used it 2.5 times a day. Sitkowska et al. [2015], however, found that multiparous cows were milked significantly more often (10.99 times) than primiparous cows (9.85 times). Winnicki et al. [2016] reported a mean daily milking frequency of 2.84 (from 1.6 to 4.4 times), which differed between primiparous and multiparous cows. The authors showed that primiparous cows, in comparison to multiparous cows, were more likely to use the milking robot up to twice a day (25% vs. 14.4%) and from 2.1 to 3 times a day (55% vs. 40.6%). Multiparous cows, on the other hand, were more often milked 3.1 to 4 (38.1% vs. 17.9%) or more (6.9% vs. 1.8%) times per day than primiparous cows. According to Kozłowska et al. [2013], the highest percentages of primiparous cows used the robots three and four times (48% and 28%, respectively), while multiparous cows were most likely to use them three times (39%) or twice (37%).

Sitkowska et al. [2015] reported significant differences in the milk yield of primiparous and multiparous cows using a milking robot (9.85 vs. 10.99 kg). A similar but statistically unconfirmed relationship was observed in our study as well. We found (Table 1) that on average 10.91 kg of milk per milking session was obtained from the multiparous cows, which was nearly 13.3% more milk than in the case of primiparous cows, whose yield per milking averaged 9.63 kg of milk.

The statistical analysis showed that daily yield differentiated the frequency of use of the milking robot by the cows (Table 2). In the primiparous cows with the lowest productivity (≤15.0 kg), this frequency was 1.84 times per day, increasing to 2.30 times at milk yield of 15.1–25.0 kg and to 2.82 times a day at 25.0 kg. Daily milking frequency increased with yield in the case of multiparous cows as well. Cows from which 15.0 kg of milk was obtained used the milking robot on average 2.24 times per day. Cows whose daily yields ranged between 15.1 and 25.0 kg milk were milked slightly more often (by 0.08 times a day - non-significant difference). The frequency of use of the robot by the most productive cows (>25.0 kg milk) was 2.67 times a day and differed from the other two groups at P ≤ 0.01.

In both the primiparous and multiparous cows, increased daily milking frequency was accompanied by

Table 1. Frequency of milking in AMS and milk yield of primiparous and multiparous cows

Tabela 1. Częstotliwość doju w AMS i wydajność mleka pierwiastek i krów wieloródek

Calving number Kolejne wycielenie	n	Daily milking frequency Dobowa częstotliwość doju		Daily milk yield, kg Dobowa wydajność mleka, kg		Milk yield per milking, kg Wydajność mleka na dój, kg	
		x̄	SD	x̄	SD	x̄	SD
Primiparous – Pierwiastki	668	2.49	0.61	23.57	6.61	9.63	2.57
Multiparous – Wieloródki	182	2.50	0.58	26.66	9.30	10.91	3.82
Ogółem i średnio – Total and average	850	2.49	0.60	24.23	7.38	9.91	2.93

n – number of milkings – liczba dojów.
x̄ – mean – wartość średnia.
SD – standard deviation – odchylenie standardowe.

Table 2. Frequency of milking in AMS and milk yield of primiparous and multiparous cows in relation to their daily yield

Tabela 2. Częstotliwość doju w AMS i wydajność mleka pierwiastek i wieloródek w zależności od poziomu wydajności dobowej

Daily yield, kg of milk Poziom dobowej wydajności, kg mleka	n	Daily milking frequency Dobowa częstotliwość doju		Daily milk yield, kg Dobowa wydajność mleka, kg		Milk yield per milking, kg Wydajność mleka na dój, kg	
		x̄	SD	x̄	SD	x̄	SD
PRIMIPAROUS – PIERWIASTKI							
≤15.0	67	1.83[Aa]	0.40	11.21[A]	2.88	6.25[a]	1.78
15.1–25.0	303	2.30[Ab]	0.45	20.56[B]	2.78	9.18[b]	1.92
>25.0	298	2.82[B]	0.59	29.41[C]	3.27	10.85[c]	2.48
MULTIPAROUS – WIELORÓDKI							
≤15.0	20	2.24[A]	1.83	12.95[A]	1.81	5.88[a]	1.22
15.1–25.0	63	2.32[A]	2.30	20.37[B]	2.85	9.05[b]	1.96
>25.0	99	2.67[B]	2.82	33.44[C]	6.63	13.10[c]	3.46
TOTAL – ŁĄCZNIE							
≤15.0	87	1.93[A]	0.41	11.61[A]	2.76	6.17[a]	1.67
15.1–25.0	366	2.30[A]	0.44	20.53[B]	2.79	9.16[b]	1.93
>25.0	397	2.78[B]	0.61	30.41[C]	4.68	11.41[c]	2.92

n – number of milkings – liczba dojów.
x̄ – mean – wartość średnia.
SD – standard deviation – odchylenie standardowe.
A,B,C – differences significant at P ≤ 0.01 – różnice istotne przy P ≤ 0,01.
a,b,c – differences significant at P ≤ 0.05 – różnice istotne przy P ≤ 0,05.

a significant increase (P ≤ 0.05) in the amount of milk obtained in one milking. Głowicka-Wołoszyn et al. [2010] reported different relationships, as the milk yield per milking decreased as milking frequency increased. Løvendahl and Chagunda [2011] also found a negative correlation between milking frequency and milk yield per milking session.

Sitkowska et al. [2015] showed that the frequency of use of the robot decreased significantly (from 2.93 to 2.63 times) over the course of lactation, and milk yield decreased from 11.35 to 9.45 kg. A decrease in the number of milkings per day with advancing lactation was also observed by Deming et al. [2013]. Table 3 shows that slightly different dependencies were observed for the cows in our study. The cows used the milking robot least often in the first trimester of lactation – 2.27 times a day on average.

During that time, their daily yield was 26.31 kg of milk and the amount of milk obtained at one time was 11.65 kg. In the second trimester the milking frequency increased (to 2.58 times) and was accompanied by a decrease in both daily yield (1.47 kg) and milk yield at one time (1.69 kg). The downward trend for both yields persisted after 200 days of lactation, while the daily milking frequency increased slightly (to 2.54 times).

In the group of primiparous cows, the daily milking frequency increased with each trimester of lactation. Furthermore, the increase in milking frequency was associated with a decrease (from 10.79 to 9.81 to 8.87 kg) in the amount of milk produced in one milking. Primiparous cows up to 100 days after calving used the robot on average 2.15 times per day. This was significantly (P ≤ 0.05) less than the means calculated for the second (2.56) and

Table 3. Frequency of milking in AMS and milk yield of primiparous and multiparous cows in relation to the stage of lactation

Tabela 3. Częstotliwość doju w AMS i wydajność mleka pierwiastek i wieloródek w zależności od fazy laktacji

Lactation stage, days Faza laktacji, dni	n	Daily milking frequency Dobowa częstotliwość doju		Daily milk yield, kg Dobowa wydajność mleka, kg		Milk yield per milking, kg Wydajność mleka na dój, kg	
		x̄	SD	x̄	SD	x̄	SD
PRIMIPAROUS – PIERWIASTKI							
≤100	173	2.15[a]	0.54	22.85	6.77	10.79	2.80
101–200	196	2.56[b]	0.59	24.71	6.72	9.81	2.67
>200	299	2.63[b]	0.58	23.30	6.32	8.87	2.06
MULTIPAROUS – WIELORÓDKI							
≤100	59	2.55[a]	0.72	34.97[A]	8.25	14.29[a]	3.68
101–200	55	2.60[a]	0.54	26.64[B]	6.43	10.41[b]	2.36
>200	68	2.44[b]	0.48	20.79[C]	6.09	8.70[c]	2.75
TOTAL – ŁĄCZNIE							
≤100	232	2.27[a]	0.59	26.31[A]	7.16	11.65[a]	3.01
101–200	251	2.58[b]	0.58	24.84[AB]	6.66	9.96	2.60
>200	367	2.54	0.57	21.94[B]	6.26	8.84[b]	2.19

n – number of milkings – liczba dojów.

x̄ – mean – wartość średnia.

SD – standard deviation – odchylenie standardowe.

A,B,C – differences significant at P ≤ 0.01 – różnice istotne przy P ≤ 0,01.

a,b,c – differences significant at P ≤ 0.05 – różnice istotne przy P ≤ 0,05.

third (2.63 times) trimesters of lactation. This may indicate that after their first calving cows learned to use the robot over the course of lactation. According to Donohue et al. [2010], to increase milking frequency at the beginning of lactation, primiparous cows can be accustomed to milking in AMS by introducing them to the robot before calving.

In successive trimesters of lactation, a systematic reduction was noted in the daily milk yield of the multiparous cows (P ≤ 0.01) and in their yield per milking session (P ≤ 0.05). The changes in daily milking frequency, on the other hand, were uneven. Cows 101–200 days after calving used the robot most frequently (2.60 times per day). A slightly lower frequency (2.55 times) was recorded in the group of cows in the first 100 days of lactation. Both of these values differed at P ≤ 0.05 from the value for multiparous cows > 200 days after calving, which used the robot on average 2.44 times per day.

CONCLUSIONS

To sum up, the cows in the herd analysed used the milking robot with an average frequency of 2.49 times a day. No significant differences in daily yield or in frequency of milking were found between primiparous and older cows. They also did not differ significantly in terms of milk yield per milking. The daily milk yield differentiated the milking frequency of the cows. Primiparous and multiparous cows with a daily yield of more than 25.0 kg of milk used the milking robot most often. In the case of both the primiparous and the multiparous cows, an increase in daily milking frequency was accompanied by an increase in the amount of milk obtained in one milking. In the group of primiparous cows, the daily milking frequency increased with each trimester of lactation. The increase in their milking frequency was found to be associated with a decrease in the amount of milk obtained per milking. In successive trimesters of lactation, the milk yield per day and per milking systematically decreased in the multiparous cows, while the changes in daily milking frequency were irregular.

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ANALIZA WYDAJNOŚCI I CZĘSTOTLIWOŚCI DOJU KRÓW RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ ODMIANY CZARNO-BIAŁEJ UTRZYMYWANYCH W OBORZE Z AUTOMATYCZNYM SYSTEMEM DOJU (AMS)

STRESZCZENIE

Celem pracy była analiza wydajności i częstotliwości korzystania przez krowy rasy polskiej holsztyńsko-fryzyjskiej z robota udojowego. Badania przeprowadzono w gospodarstwie, w którym w oborze wolnostanowiskowej rusztowej na 120 osobników zamontowany był dwustanowiskowy robot Astronaut firmy Lely. Materiały do pracy pochodziły z systemu do zarządzania stadem i obejmowały dane z 850 dojów. Analizowano dobową wydajność mleka (w kg), liczbę dojów w ciągu doby oraz przeciętną wydajność mleka w doju, a czynnikami doświadczalnymi były: kolejna laktacja (pierwiastki i wieloródki), dobowa wydajność mleka (≤15 kg; 15,1–25,0 i >25,0 kg) oraz faza laktacji (≤100 dni; 101–200 i >200 dni). Stwierdzono, że w analizowanym stadzie krowy korzystały z robota udojowego ze średnią częstotliwością 2,49 razy na dobę. Nie wykazano istotnych różnic w dobowej wydajności i częstotliwości doju pomiędzy pierwiastkami, a krowami starszymi. Nie różniły się one także istotnie ze względu na wydajność mleka w jednym doju. Poziom dobowej wydajności różnicował częstotliwość doju. Najczęściej z robota udojowego korzystały pierwiastki i wieloródki o wydajności dobowej przekraczającej 25,0 kg mleka (odpowiednio 2,82 i 2,67 razy na dobę). Zarówno w przypadku pierwiastek, jak i w grupie wieloródek wzrostowi dobowej częstotliwości doju towarzyszyło zwiększanie się ilości mleka pozyskiwanego w jednym doju. W grupie pierwiastek dobowa częstotliwość doju zwiększała się w kolejnych tercjach laktacji. Stwierdzono także, że ze wzrostem częstotliwości ich doju związane było zmniejszanie się ilości mleka pozyskiwanego w jednym doju. W kolejnych tercjach laktacji w grupie wieloródek systematycznie obniżała się dobowa wydajność mleka i jego ilość w przeliczeniu na dój, nieregularnie zmieniała się natomiast dobowa częstotliwość doju.

Słowa kluczowe: rasa polska holsztyńsko-fryzyjska, automatyczny system doju, pierwiastki, wieloródki, częstotliwość doju, dobowa wydajność mleka, faza laktacji