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EFFECT OF LACTATION NUMBER AND AVERAGE DAILY MILK YIELD IN COMPLETE LACTATION ON THE DRY PERIOD LENGTH OF POLISH HOLSTEIN-FRIESIAN COWS

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Abstract. The aim of the study was to determine the effect of average daily milk yield in complete lactation and lactation number in cows producing at least 8,500 kg of milk in 305-day lactation on the length of the dry period before the next lactation. A total of 1,965 complete, extended lactations in Polish Holstein-Friesian cows subject to use value assessment were analysed. The average complete-lactation daily milk yield was shown to influence the length of the dry period. The average dry period length was 44 days. Dry period length decreased in successive milk-yield groups, from 50 days (average daily yield up to 25 kg of milk) to 28 days (average daily yield over 35 kg in complete lactation). Thus it was confirmed that as milk yield increased, it was more difficult to end lactation. The shortest dry period (only 25 days) was recorded in the youngest cows (second and third lactation) with the highest average daily milk yield in complete lactation (>35 kg). In the oldest cows, i.e. those in their sixth lactation and higher, no statistically significant differences were shown in the length of the dry period depending on daily yield.

Key words: cow, milk yield, lactation, dry period length.

INTRODUCTION

Lactation is maintained by regular milking. Without this stimulus, secretion stops, existing secretory cells undergo apoptosis, and new ones are no longer produced (Wilde et al. 1999). According to Knight (2005), the modern dairy cow should not only have high levels of milk yield, but also longer lactation. One of the effects of very high milk performance is prolongation of the period of milk production after calving, and thus a shorter dry period or even no dry period (Krzyżewski and Reklewski 2003).

For the milk-producing cells in the udder to function normally, the cow must be effectively dried off about 45–60 days before the expected date of parturition (Kuhn et al. 2005). Temporary cessation of milk production is essential for the creation of suitable conditions in the body for rapid foetal growth, normal parturition, high fertility, high milk yield, and high lactation persistency in the subsequent lactation (Malinowski 2006; Salamończyk and Guliński 2011). The results of many studies (Annen et al. 2003; Fernandez et al. 2003; Pytlewski et al. 2009; Soleimani et al. 2010; Salamończyk and Guliński 2011) show that cows dried off about 60 days before

calving produce more milk in the subsequent lactation than those dried off between 30 and 40 days. A study evaluating milk production on dairy farms reported a milk yield loss of 1,000 kg when the dry period was omitted (Steenefeld et al. 2013). Pezeshki et al. (2010) attributed the reduced milk yield in cows with a shortened dry period to less developed mammary glands. However, shortening or omitting the dry period of dairy cows can improve the energy balance and metabolic status in the next lactation through reduced milk production and similar or increased feed intake in early lactation (Kok et al. 2021). Cows with a 60 d dry period were in a negative energy balance (NEB) during the first 14 weeks of their lactation, while cows with a 30 d dry period were in a NEB for 8 to 12 weeks, and cows with no dry period were in a NEB for 4 to 5 weeks (van Knegsel et al. 2014). Boustan et al. (2021) demonstrated that even during heat stress, shortening of the dry period improved the metabolic state of dairy cows without reducing total milk yield. Research by Salamończyk and Guliński (2011) also showed that cows with the shortest dry periods (up to 45 days) had the highest lactation persistency in the next lactation.

While there have been many studies assessing the effect of the length of the dry period (short or absent) on milk yield in the next lactation, little is known of the relationship between the cow's daily milk yield level and the possibility of ending lactation. Therefore the aim of the study was to analyse the effect of average daily milk yield obtained in complete lactation and lactation number in high-yielding dairy cows on the length of the dry period preceding the next lactation.

MATERIAL AND METHODS

Milk from Polish Holstein-Friesian cows raised on private farms and subject to use value assessment was analysed. Lactation data were obtained from the SYMLEK database of cows kept in Łuków County (Lublin Voivodeship) in 2010–2015. Only cows whose complete lactation was extended, i.e. at least one day longer than standard lactation, and which produced at least 8,500 kg milk in standard (305-day) lactation, were selected for analysis. A total of 1,965 extended complete lactations were selected and analysed. The number of lactations analysed for each lactation length was as follows: lactations lasting from 306 to 367 days – 870 (44.3%); from 368 to 430 days – 552 (28.1%); more than 430 days – 543 (27.6%). Data for analysis were taken from milk records of 431 dairy herds kept by the Polish Federation of Cattle Breeders and Dairy Farmers in Warsaw, which performs milk recording of dairy and dual-purpose breeds in Poland. The organization is a member of the International Committee for Animal Recording (ICAR), the World Holstein-Friesian Federation (WHFF), and the European Holstein & Red-Holstein Confederation (EHRC). The evaluation employs method A and is carried out by authorized Federation employees. Physical and chemical evaluation of milk includes the following parameters: percentage fat content, percentage protein content, percentage lactose content, percentage dry matter content, urea level, and somatic cell count. It is performed by laboratories accredited by the Polish Accreditation Centre, which apply a quality system in accordance with Standard PN-EN ISO/IEC 17025, following ICAR guidelines.

The effect of the following factors was analysed:

- average daily milk yield per complete lactation (≤ 25.0 kg; 25.1–35.0 kg; ≥ 35.0 kg),
- lactation number (2 and 3; 4 and 5; 6 and higher)

For a precise characterization of the population, actual yields of milk were expressed as energy-corrected milk (ECM), which contains 3.50% fat and 3.20% protein, according to the following formula (Bernard 1997):

$$\text{ECM (kg)} = (0.3246 \times \text{kg milk}) + (12.86 \times \text{kg fat}) + (7.04 \times \text{kg protein})$$

Milk energy value (E) was calculated according to the following formula (Kleiber 1961):

$$E \text{ (kcal/kg)} = (\% \text{ fat} \times 92) + (\% \text{ protein} \times 58.6) + (\% \text{ lactose} \times 39.5)$$

The results were then subjected to statistical analysis using Statistica software according to the following linear model:

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

where:

Y_{ijk} – phenotypic value of trait (dry period length),

μ – overall mean of trait,

a_i – average daily milk yield per lactation (≤ 25.0 ; 25.1–35.0; >35.0 kg),

b_j – lactation number (2 and 3; 4 and 5; 6 and higher),

$(ab)_{ij}$ – interaction: average daily milk yield per lactation \times lactation number,

e_{ijk} – residual error.

The analysis included one-way and two-way ANOVA with interaction, using Tukey's honestly significantly difference procedure. Significance of differences between means was checked using Duncan's test ($P < 0.01$; $P < 0.05$). Results are presented as mean values and standard deviation (SD).

RESULTS

The analysis was conducted on data from 1,965 complete (extended) lactations, lasting at least 306 days. More than 72% of the lactations analysed lasted from 306 to 430 days (up to 14 months). Lactations of Polish Holstein-Friesian cows with actual yield above 8,500 kg of milk obtained in 305-day lactation were chosen for the analysis. Table 1 presents an overall characterization of the population of highly productive cows. The average daily milk yield obtained in complete lactation was 28.4 kg. The average somatic cell count in 1 ml of milk was high, at 393,000. ECM yield was 10,135 kg and 12,223 kg in standard and complete lactation, respectively.

Table 1. Descriptive statistics for the study population of cows

Variable	Mean	SD	Minimum	Maximum
Complete lactation length, days	402	85.9	306	622
ECM yield in standard lactation, kg	10,135	1,126.6	7,642	17,946
ECM yield in complete lactation, kg	12,223	2,398.4	8,285	29,362
Average daily milk yield in complete lactation, kg	28.4	3.34	18.5	49.7
Average energy value of milk in complete lactation, kcal/kg	765	60.9	489	1,014
Average somatic cell count in complete lactation, x1,000/ml	393	463.0	18	5,059

Analysis of the effect of the average daily milk yield of the cows revealed statistically significant ($P < 0.01$) differences in the length of the dry period (Table 2). The average dry period length was 44 days. The largest number of cows (83.5%) had average daily milk yield between 25.1 and 35 kg. The length of the dry period in successive daily yield groups decreased from 50 days (average daily yield up to 25 kg) to 28 days (over 35 kg in complete lactation). This confirmed that as milk yield increased, the length of the dry period decreased (Table 3).

Table 2. Effect of average daily milk yield in complete lactation on the length of the dry period (days)

Average daily milk yield in complete lactation, kg	N	%	Dry period length	
			mean	SD
≤ 25.0	250	12.7	50 ^A	41.4
25.1–35.0	1,640	83.5	44 ^A	34.2
>35.0	75	3.8	28 ^B	30.5
Total/average	1,965	100	44	35.3

A, B – means within a column followed by different letters differ significantly at $P < 0.01$.

Table 3. Frequency of short and long dry periods depending on average daily milk yield in complete lactation

Average daily milk yield in complete lactation, kg	Dry period length, days						Total	
	≤30		31–45		>45		N	%
	N	%	N	%	N	%		
≤25.0	81	32.40	22	8.80	147	58.80	250	100
25.1–35.0	519	31.65	190	11.58	931	56.77	1,640	100
>35.0	40	53.33	5	6.67	30	40.00	75	100

The results of the calculations showing the influence of average daily milk yield in complete lactation and lactation number are presented in Table 4. The average length of the dry period was very similar in all lactation groups (43 and 45 days). Significant differences ($P < 0.05$) in dry period length were observed between cows in their second or third lactation and those in their fourth or fifth lactation, within groups distinguished by average daily milk yield in complete lactation. The shortest dry period, lasting only 25 days, was noted in the youngest cows (2nd and 3rd lactation) with average daily milk yield above 35 kg. The longest dry periods were noted in the cows with the lowest average daily milk yield in complete lactation (≤ 25.0 kg); the average dry period length was 52 (4th or 5th lactation) or 53 days (2nd or 3rd lactation). In the oldest group of cows, i.e. in their sixth lactation or higher, there were no statistically significant differences in the length of the dry period depending on daily yield.

Table 4. Effect of lactation number and average daily milk yield in complete lactation on the length of the dry period (days)

Average daily milk yield in complete lactation, kg	Lactation number								
	2 and 3			4 and 5			6 and higher		
	N	mean	SD	N	mean	SD	N	mean	SD
≤25.0	121	53 ^a	41.1	73	52 ^a	43.1	56	41 ^a	43.6
25.1–35.0	851	45 ^a	34.6	425	44 ^a	35.4	364	43 ^a	36.1
>35.0	50	25 ^b	28.8	17	28 ^b	36.2	8	34 ^a	48.1
Total/average	1,022	45	35.5	515	45	36.7	428	43	37.2

N = 1,965

a, b – means within a column followed by different letters differ significantly at $P < 0.05$.

DISCUSSION

In recent years the average milk yield of cows has increased significantly due to genetic and nutritional advances. Cows are also able to maintain high levels of production much longer than the minimum recommended 305 days (Österman and Bertilsson 2003; Kolver et al. 2006; Auld-ist et al. 2007). The present study showed that higher daily milk yield significantly shortens the dry period before the subsequent lactation. The higher the daily milk yield, the more difficult it is to finish lactation. Januś and Borkowska (2010) confirmed the significant effect of the level of milk production on dry period length. Cows from which up to 10 kg of milk was obtained in the final milking before the dry period had an average dry period of 81 days, in contrast to 55 days in the case of 20 kg yield. Moreover, in the group of cows whose yield on the final milking day was above 20 kg, there were cases of omission of the dry period. Earlier research by Schaeffer and Henderson (1972) found that cows with the highest yield had the shortest subsequent dry periods. Makuza and McDaniel (1996) concluded that prior milk yield should be taken into account in determining the effect of dry period length on later milk yield. Later, Bachman and Schairer (2003) confirmed that low production during lactation has a tendency to increase dry period

length, and that this extension of the previous dry period results in lower milk production in the subsequent lactation. According to Kok et al. (2016), reduced milk yield can be compensated for by improved health and fertility in cows, which can extend their viability.

High yield before the dry period causes the animal discomfort due to the high osmotic pressure within the udder. Drying off these cows can increase the risk of *mastitis* (Krzyżewski and Reklewski 2003). According to Rajala-Schultz et al. (2005), for every 5 kg increase in milk production before the dry period, the risk of udder infection in the peripartum period increases by 77%. Therefore one way to prevent peripartum problems in high-yield cows is to adopt a strategy of delaying conception after calving, which at the same time prolongs lactation. A plan to delay conception after calving reduces the number of times the cow calves per year, but also reduces the number of periods of health risk (*mastitis*, lameness, or metabolic problems in early lactation) associated with calving (Ingvartsen et al. 2003), and makes it possible to improve the longevity and lifetime yield of dairy cows. Delaying the next conception should improve lactation persistency, because pregnancy negatively affects milk yield, especially in the last trimester (Brotherstone et al. 2004; Knight 2005; Penasa et al. 2016).

The conventional 40–60-day interval before the next lactation is particularly necessary for primiparous cows. A dry period between lactations allows the mammary epithelial component to regress and proliferate, allowing for maximum milk production during the subsequent lactation (Capuco et al. 1997). Many studies have shown that milk yield in primiparous cows decreased when the dry period was reduced from 56 to 35 days, whereas shortening the dry period did not affect the milk yield of multiparous cows (Annen et al. 2004; Pezeshki et al. 2007; Klusmeyer et al. 2009). Steeneveld et al. (2014) evaluated the productivity of cows in lactations not preceded by a dry period or preceded by a short one (up to 30 days) in comparison to yield in lactation following a 60-day dry period. The average total milk yield in these cows was 9,341, 10,499 and 10,795 kg, respectively, for cows with no dry period (DP) and with a 30-day and 60-day DP. Multiparous cows had smaller production losses (987 kg) than primiparous cows (2,132 kg) in lactations not preceded by a dry period, compared to a 60-day DP. The authors recommend a 30-day dry period for multiparous cows with high milk production (about 25 kg/day for the 12 weeks before expected calving). Pezeshki et al. (2007), Annen et al. (2004) and Santschi et al. (2011) also report that the reduction in milk production following a short DP or no DP was greater in primiparous cows than in multiparous cows. This is confirmed by Swanson (1965) in a study comparing the yield of twin cows up to their fourth lactation, in which a 60-day dry period was used in one twin, while the other was milked up to the next lactation (no dry period). Twins milked continuously (without a dry period) produced 25% and 38% less milk in their second and third lactation, respectively, than twins dried out 60 days before calving. In a study by Niozas et al. (2019), primiparous cows were dried out at higher yield levels than multiparous cows, which according to the authors indicates greater persistency. Milk yield in the previous lactation, as well as the number of days open (i.e. from calving to conception), influences the length of the dry period, which in turn affects milk yield in the subsequent lactation (Bachmann and Schairer 2003). A low level of production in the current lactation will have a tendency to prolong the dry period. Each dairy cow has its own optimal dry period length, which maximizes its profitability during successive lactations. Many factors influence when the cow will be dried out before the next lactation. Therefore further research will include aspects such as assessment of the effect of the level of milk production at peak lactation or the energy value of the milk produced in complete lactation on the length of the dry period of cows in extended lactation.

CONCLUSION

Ending a cow's lactation is an element of herd management. The decision depends on feed resources, daily yield, lactation number, the farmer's need for a convenient schedule, replace-

ment heifers, uncontrolled events (e.g. early parturition or abortion), and unintended delay of the dry period or of mating (conception) (Bachman and Schairer 2003). The research confirmed that cows with high yield have shorter dry periods. A dry period of suitable length enables the involution, proliferation and re-differentiation of the secretory tissue of the udder. Therefore in the youngest cows with high milk yield in the entire lactation, whose udder tissue is still developing, the dry period should last about 40–60 days. Short dry periods can only be used in older animals, even high-yielding ones. However, further research is needed to determine the optimum time of rest following milk production for individual age groups and milk production levels.

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WPŁYW KOLEJNEJ LAKTACJI ORAZ ŚREDNIEJ DOBOWEJ WYDAJNOŚCI MLEKA W LAKTACJI PEŁNEJ KRÓW RASY POLSKIEJ HOLSZTYŃSKO- -FRYZYJSKIEJ NA DŁUGOŚĆ OKRESU ZASUSZENIA

Streszczenie. Celem pracy była ocena wpływu średniej dobowej wydajności mleka uzyskanej w laktacji pełnej oraz kolejnej laktacji krów produkujących co najmniej 8500 kg mleka w laktacji 305-dniowej na długość okresu zasuszenia przed następną laktacją. Przebadano 1965 laktacji pełnych przedłużonych krów rasy polskiej holsztyńsko-fryzyjskiej, będących pod oceną wartości użytkowej. Wykazano istotny wpływ poziomu średniej dobowej wydajności mleka w laktacji pełnej na długość okresu zasuszenia. Średnia długość okresu zasuszenia ocenianych zwierząt wynosiła 44 dni. Okres zasuszenia w kolejnych grupach uwzględniających poziom dobowej wydajności mleka ulegał skróceniu z 50 dni (średnia wydajność dobową do 25 kg mleka) do 28 dni (średnia wydajność dobową mleka powyżej 35 kg w laktacji pełnej). Potwierdzono zatem, że wraz ze wzrostem wydajności mleka trudniej zakończyć laktację. Najkrótszy okres zasuszenia występował u krów najmłodszych (w laktacjach 2. i 3.) z najwyższą średnią dobową wydajnością mleka w laktacji pełnej (>35 kg) i wynosił zaledwie 25 dni. Nie stwierdzono istotnych statystycznie różnic w długości okresu zasuszenia w zależności od wydajności dobowej u krów najstarszej grupy, tj. w 6. i następnym laktacjach.

Słowa kluczowe: krowy, wydajność mleka, laktacja, długość okresu zasuszenia.