

Original study

Effect of the first and next calvings of cows and their milk production level on the relationship between dry period length and milk yield and its composition in the subsequent lactation

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Abstract

The effect cow age and milk production level was analyzed on the relationship between dry period length and milk yield and composition in the subsequent lactation. The GLM and CORR PEARSON procedures of the SAS package were used in the statistical calculations. It is shown that in terms of milk yield in the subsequent lactation, a dry period of 40-60 days was the most favourable. In particular in primiparous cows it was found that in terms of milk yield, shortening the dry period is less favourable than extending it beyond the 41- to 60-day standard. A dry period of 21-40 days can be offered to multiparous cows without significant milk losses in the subsequent lactation. Eliminating or shortening the dry period should exclude cows after first calving. It seems that a dry period of 21-40 days can also be offered to high-producing cows (≥ 8000 kg milk) because their milk yield, in relation to cows dried for 41-60 days, was lower by 3.5%. Shortening the dry period has a positive effect on the concentration of basic milk components such as fat and protein, causing them to increase. Dry period length had no effect on milk lactose content.

Keywords: cows, primiparous, multiparous, dry period, milkiness

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Introduction

The dry period (the non-lactating stage in the cow's production cycle) is the time between the natural or forced end of lactation and calving. During the dry period the mammary gland goes through three stages: active involution, steady state involution, and colostrogenesis (Philpot *et al.* 2006). The mechanism of mammary involution suppresses milk production. During the steady state involution that lasts 2-3 weeks, mammary activity is arrested and no product is secreted (Malinowski 2004). The colostrum formation period (the last two weeks prepartum) is characterized by renewed proliferation and activity of mammary epithelium, leading to production of colostrum (Kuczaj *et al.* 2009), and of milk after parturition (Malinowski 2004). During this period, there are increases in volume of secretion and concentration of milk nutrients such as milk fat, lactose and casein, and a decrease in lactoferrin concentration, which is associated with the loss of antimicrobial properties, especially with regard to coliform bacteria (Philpot *et al.* 2006).

The optimum length of the dry period in dairy cattle has been debated since the early 19th century (Annen *et al.* 2004b). The 60-day dry period was adopted at the beginning of the 20th century. However, the duration of this period needs to be revised because intensive breeding work that has been carried out over the last 40 years, coupled with improvements in environmental conditions caused the milk yield of cows to double in many countries. Higher milk yields increased changes in cow productivity, among others by extending lactations (Sawa & Bogucki 2009), which possibly indicates that cows are able to produce milk for a long time, as a result of which the dry period could be shorter.

Most studies have analysed dry period length in the context of its effect on cow's milk yield in the subsequent lactation. The results show that excessively shortened or omitted dry periods cause the milk yields to vary from a 1% increase to a 10% decrease (Bachman & Schairer 2003), with some authors reporting much higher losses of 12-40% (Kuczaj *et al.* 2009, Monroe & Amaral-Philips 2005, Philpot *et al.* 2006, Annen *et al.* 2004a, Sawa *et al.* 2012, McGuire *et al.* 2004, Rastani *et al.* 2005) and over 50% in the case of primiparous cows (Annen *et al.* 2008). More conclusive results were reported for dry periods extended beyond the 60-day standard, because they all caused the milk yields to decline (Kuhn *et al.* 2007, Sawa *et al.* 2012, Berry & Hilerton 2007, Monroe & Amaral-Philips 2005, Waldner 2007). From an economic perspective, a discussion of milk composition may prove particularly important in countries which have milk quotas (Soleimani *et al.* 2010, Grummer & Rastani 2004, Annen *et al.* 2004b).

The objective of the study was to analyse the effect of cow age and milk production level on the relationship between dry period length and milk yield and composition in the subsequent lactation, based on a large body of data collected from performance recorded cows.

Material and methods

Data for the study were obtained from SYMLEK database and concerned milk performance of 10 139 Polish Holstein-Friesian cows representing the active population in Pomerania and Kujavia. They first calved in 2006 and were used or culled before the end of 2012. Calculations were made of the length of 18 280 dry periods, which were classified by duration (0-20, 21-40, 41-60, 61-80, 81-100, >100 days).

Analysis of variance (GLM procedure; SAS 2008) was used to evaluate the effect of dry period length in primiparous and multiparous cows and milk yield in the previous lactation (<8 000 kg and \geq 8 000 kg) on days in milk, milk yield, and milk fat, protein, lactose and solids content in the subsequent full lactation. Significant differences were determined using the Scheffe test.

The CORR PEARSON procedure (SAS 2008) was used to calculate the coefficients of correlation between dry period length and milk yield and composition in the subsequent lactation.

Results and discussion

Out of the 18 280 dry periods, most (41.5 %) were 40-60 days long and fell within the range of 6-8 weeks recommended for use in commercial practice. With the advancing age of cows, the percentage of dry periods of 0-21, 21-40 and 40-60 days decreased and the percentage of longer periods increased (Table 1). Regardless of age, dry period length caused statistically significant differences in milk yield in the subsequent production cycle, with the largest effect observed for primiparous cows.

Independently of age, the highest milk yield was recorded in cows dried for 40-60 days. Salamończyk & Guliński (2011) found that cows assigned a 46- to 60-day dry period were characterized by the highest energy-corrected milk yield (ECM; the amount of milk produced in relation to the amount of feed consumed) during a standard lactation and the lowest decrease in milk yield during its course. The same dry period interval was reported to be the most beneficial for the highest milk yield in the upcoming lactation by the authors cited by Gulay *et al.* (2003b).

Both short and extended dry periods were found to reduce milk yield in the subsequent lactation, with greater differences found for the youngest cows. In primiparous cows in particular, short dry periods were found to be less favourable in terms of milk yield than those extended beyond the 41- to 60-day standard. Reducing the dry period to 21-40 days caused the next lactation milk yield to decrease by around 6 % in primiparous cows and by around 3.5 % in multiparous cows. According to Church *et al.* (2008), shortening the dry period in primiparous cows to 30-40 days negatively affects their milk yield in the subsequent lactation, but this relationship was not observed in multiparous cows. It appears that multiparous cows can be assigned a 21- to 40-day dry period without a significant reduction in milk yield in the subsequent lactation. Likewise, Overton (2005) claims that in primiparae, the dry period can be reduced to 30-40 without affecting their next lactation performance.

Shortening the dry period to 0-20 days in primiparous cows is not advisable because it reduces milk yield in the subsequent lactation by around 20 %, compared to around 16 % in multiparous cows. Kuhn *et al.* (2005) showed that dry periods shorter than 40 days had a more negative effect on primiparous than multiparous cows, which according to the authors resulted from the differences in physiological maturity. Short or omitted dry periods can interfere with mammary development in primiparous cows, causing the milk yield to decrease in subsequent lactations (Annen *et al.* 2004b).

Our results show that milk yield in the subsequent lactation is adversely affected by dry periods longer than 80 days, because they reduce milk yield by around 5 % regardless of

Table 1
Effect of dry period length in primiparous and multiparous cows on milk yield and composition in the subsequent production cycle

Age of dry cows	Dry period length, days						Significance of differences	
	0-20 1	21-40 2	41-60 3	61-80 4	81-100 5	>100 6		
Primiparous	Performance indicators of the cows							
	No. of periods, %	375 (4.70)	1 184 (15.0)	3 431 (43.5)	1 976 (25.01)	469 (6.0)	453 (4.7)	-
	Days of milking	352	364	370	369	370	379	1-3,4*, 1-6**
	Milk in lactation, kg	6 941	8 135	8 688	8 547	8 268	8 287	1-2,3,4,5,6**, 2-3,4**
	% in relation to group 3	79.9	93.6	100.0	93.4	95.2	95.4	-
	Fat, %	4.38	4.24	4.22	4.21	4.22	4.21	1-2,3,4,5,6**
	Protein, %	3.62	3.44	3.37	3.33	3.31	3.35	1-2,3,4,5,6**, 2-3,4,5,6**, 3-4,5**
	Lactose, %	4.76	4.76	4.76	4.76	4.76	4.74	-
	Dry matter, %	13.41	13.11	13.03	12.99	12.98	12.99	1-2,3,4,5,6**, 2-3**, 2-4*
	No. of periods, %	416 (4.0)	1 286 (12.4)	4 312 (41.5)	2 859 (27.5)	818 (7.9)	701 (6.7)	-
Multiparous	Days of milking	350	362	364	367	369	362	1-4,5*, 1-6**
	Milk in lactation, kg	7 340	8 458	8 761	8 638	8 583	8 266	1-2,3,4,5,6**, 2-3*, 3-6**
	% in relation to group 3	83.8	96.5	100.0	98.6	97.9	95.7	-
	Fat, %	4.32	4.25	4.24	4.22	4.18	4.22	1-5**
	Protein, %	3.52	3.38	3.33	3.30	3.27	3.29	1-2,3,4,5,6**, 2-3,4,5,6**, 3-4,5,6**
	Lactose, %	4.71	4.72	4.73	4.73	4.71	4.72	-
	Dry matter, %	13.26	13.05	13.01	12.95	12.88	12.95	1-2,3,4,5,6**, 2-4*, 2-5**, 3-4*, 3-5**

**P≤0.01, *P≤0.05

cow age. Kuhn *et al.* (2006) advise avoiding dry periods longer than 70 days because of a reduction in milk yield in the subsequent lactation.

Taking all the cows into account, our findings are in agreement with the results reported by Węglarzy (2009) that short (<1 month) and excessively long (>3 month) dry periods have negative effects on milk yield in the subsequent lactation. This also supports the earlier findings of Borkowska *et al.* (2006).

The main components of milk that determine its nutritional value and processing suitability are fat and protein. When analysing the effect of dry period length on milk protein content in the subsequent lactation, it was found that regardless of cow age, it was the highest when the dry period was 0-20 days. Protein content was found to decrease with the extension of the dry period, with differences between the extreme groups of 0.27 % in primiparous cows and of 0.23 % in multiparae. This is completely confirmed by the coefficients of correlation shown in Table 3. Grummer & Rastani (2004) and Rastani *et al.* (2005) reported that shortening the dry period from 8 to 4 weeks and its elimination caused an increase in milk protein percentage, justifying it on the grounds of an inverse relationship between milk yield and milk protein percentage in response to a change in dry period length. A similar tendency was noted by Soleimani *et al.* (2010) who reported that the milk of cows given a 35-day dry period had a higher milk percentage compared to traditionally dried cows. Similar to Annen *et al.* (2004b), these authors believe that the increase in milk protein percentage may result from the decline in milk yield, which improves the energy balance and may therefore be a way of providing amino acids and energy for protein synthesis. Likewise, Bernier-Dodier *et al.* (2011) found milk protein content to be higher in cows dried for 35 days (3.33 ± 0.06 %) compared to those dried for 65 days (3.14 ± 0.05 %). Sawa *et al.* (2012) found protein content to decrease (from 3.54 % to 3.24 %) with extension of the dry period (0 days - >100 days). A negative correlation ($r = -0.160xx$) between dry period length and milk protein content was reported by Borkowska *et al.* (2006). Also the findings of Kuhn *et al.* (2006) indicate that shortening the dry period had a positive effect on milk protein percentage and this pattern concerned all animals regardless of lactation number. In a study by Rémond *et al.* (1997), the proportion of casein in milk protein remained unchanged both in the cows managed without the dry period and in the control cows.

Changes in the fat content of milk from lactating cows after different dry period lengths were slightly smaller than for protein, but they tended to follow the same pattern, with the extension of the dry period being paralleled by a decrease in fat content (differences between the extremes groups of 0.17 % in primiparous and 0.10 % in multiparous cows). Borkowska *et al.* (2006) showed that longer extension periods were generally associated with lower fat content. A similar relationship was reported by Gulay *et al.* (2003a) and Rastani *et al.* (2005). When analysing the effect of dry period length on the nutrient content of milk from second, third and fourth lactation cows, Kuhn *et al.* (2006) also showed that shortening the dry period increased milk fat percentage.

Lactose content remained similar in primiparous and multiparous cows regardless of dry period length. Among the studies concerning the effect of dry period length, some indicate a decrease in lactose content while others show no relationship between dry period length and lactose milk content. Annen *et al.* (2004a) suggest that reduced milk yield without a decrease in lactose synthesis in cows managed without the dry period may be due to the

Table 2
Effect of dry period length and milk production level in the lactation preceding dry-off on milk yield and composition in the subsequent production cycle

Milk production level in the lactation preceding dry-off	Performance indicators of the cows		Dry period length, days				Significance of differences	
	0-20 1	21-40 2	41-60 3	61-80 4	81-100 5	>100 6		
Milk, kg <8000	No. of periods, %	411 (4.0)	1 357 (13.4)	4 186 (41.3)	2 724 (26.9)	743 (7.3)	718 (7.1)	-
	Days of milking	344	351	357	357	355	358	-
	Milk in lactation, kg	5 871	6 879	7 303	7 250	7 149	7 144	1-2,3,4,5,6**, 2-3,4**
	% in relation to group 3	80.4	94.2	100.0	99.3	97.9	97.8	-
	Fat, %	4.39	4.32	4.30	4.27	4.22	4.24	1-4*, 1-5,6**, 2,3-5*
	Protein, %	3.58	3.42	3.35	3.31	3.27	3.32	1-2,3,4,5,6**, 2-3,4,5,6**, 3-4,5,6**, 4-5*, 5-6*
	Lactose, %	4.72	4.73	4.73	4.73	4.71	4.71	-
	Dry matter, %	13.36	13.15	13.07	130.1	12.91	12.98	1-2,3,4,5,6**, 2-4,5,6**, 3-5**
	No. of periods, %	380 (4.7)	1 113 (13.7)	3 557 (43.7)	2 111 (25.9)	544 (6.7)	436 (5.3)	-
	Days of milking	359	379	378	381	389	384	1-2*, 1-3,4,5,6**
Milk, kg ≥8000	Milk in lactation, kg	8 535	10 041	10 407	10 344	10 271	10 136	1-2,3,4,5,6**, 2-3*
	% in relation to group 3	82.0	96.5	100.0	99.4	98.7	97.4	-
	Fat, %	4.31	4.15	4.15	4.14	4.16	4.18	1-2,3,4**, 1-5*
	Protein, %	3.56	3.39	3.35	3.31	3.31	3.31	1-2,3,4,5,6**, 2-3,4,5,6**, 3-4,5,6**, 3-6*
	Lactose, %	4.74	4.76	4.76	4.76	4.75	4.75	-
	Dry matter, %	13.29	12.98	12.96	12.91	12.92	12.96	1-2,3,4,5,6**

**P<0.01, *P<0.05

Table 3
Coefficients of correlation between dry period length and milk performance traits in the next production cycle

Performance indicators of the cows	Coefficients of correlation depending on milk production level in the lactation preceding dry-off		
	General	age of dry cows	dry-off
Days of milking	0.02018**	Primaparous	≥8000, kg
		Multiparous	0.04566 **
Milk in lactation, kg	0.02018 **	Primaparous	0.03060 **
		Multiparous	0.05520 **
Fat, %	-0.02539 **	Primaparous	-0.04211 **
		Multiparous	-0.01530
Protein, %	-0.13229 **	Primaparous	-0.12381 **
		Multiparous	-0.15022 **
Lactose, %	-0.01223	Primaparous	-0.01529
		Multiparous	0.00806
Dry matter, %	-0.06093 **	Primaparous	-0.07168 **
		Multiparous	-0.05328 **

**P<0.01, *P<0.05

smaller number of mammary secretory cells. Bernier-Dodier *et al.* (2011) found no differences in lactose percentage between a 65-day ($4.59 \pm 0.03\%$) and 31-day dry period ($4.57 \pm 0.04\%$). Meanwhile, Soleimani *et al.* (2010) reported that milk from cows having a traditional dry period (60 days) contained 4.56% lactose compared to 4.71% in the experimental group (35 days).

As the dry period was extended, milk solids content in the subsequent lactation decreased in both primiparous and multiparous cows, but a greater decline was noted in the group of younger cows.

It was found that with increasing milk production level during the lactation preceding drying off, the proportion of dry periods of 0-21, 21-40 and 40-60 days increased and that of longer dry periods decreased (Table 2). In the group of cows with different milk yields in the lactation preceding drying off, there was a statistically significant effect of dry period length on milk yield and composition except for lactose content. Regardless of the milk yield level in the lactation preceding the dry-off, extension of the dry period to 60-80 days and longer decreased milk yield to a small extent (around 1-2.6%). Shortening the dry period to 21-40 days caused smaller losses (3.5%) in the group of cows yielding ≥ 8000 kg milk compared to cows producing less milk (5.8%). Also Farries & Hoheisel (1989) showed that compared to low-yielding cows, high-producing cows are less sensitive to shortening the dry period, which the authors attribute to the effect of constant milking on milk yield in the subsequent lactation. Based on a review of literature, Kuczaj *et al.* (2009) suggest that cows with a daily milk yield of at least 20 kg 60 days before calving should be further milked until, for example, 30 days before calving. The highest losses (19.6% and 18%) were found when the dry period was shortened to 20 days or eliminated, in which case higher-producing cows proved also less sensitive. It can be hypothesized that high-producing cows can maintain secretion even during continuous lactation, without the dry period, because selection for milk yield increased their endogenous secretion of somatotropin (Kazmer *et al.* 1986). Meanwhile, Kuhn *et al.* (2005) showed that a short dry period (<40 days) for high producing cows that bred back early in lactation proved to be the worst combination in terms of maximizing subsequent lactation milk yield.

The results of many authors (Church *et al.* 2008, Kuhn *et al.* 2005, Borkowska *et al.* 2006, Węglarzy 2009, Sawa *et al.* 2012) indicate that shortening the dry period to less than 30 days limits milk yield in the next production period. Inconsistent results with regard to the effects of shortening the traditional dry period to around 30 days are described by Bachman & Schairer (2003). Through a review of literature, they determined that shortening the dry period may cause the next lactation milk yields to vary from a 1% increase to a 10% decrease. They also showed that the results obtained can be affected by factors such as experimental approach: retrospective analysis of observational data vs. planned trials. Not without significance is the random choice of animals taking part in experiments. Other important factors affecting the results obtained include the genetic origin of cows and herd management strategies for experimental animals (Soleimani *et al.* 2010, Bachman & Schairer 2003, Annen *et al.* 2004b).

In the group of cows which milk yield in the lactation preceding the dry period was up to 8000 kg, the content of fat, protein and solids was found to decrease as the dry period was extended, with differences of 0.15%, 0.31% and 0.38% between the extreme groups. This tendency did not occur in the group of cows which milk yield in the lactation preceding

the dry period exceeded 8000 kg. In this group, the highest fat, protein and solids content was found for a dry period of 2-20 days; extension of this period caused the content of these components to decline, but the changes were not regular.

In summary it is concluded that in terms of milk yield in the subsequent lactation, a dry period of 40-60 days was the most favourable. In particular in primiparous cows it was found that in terms of milk yield, shortening the dry period is less favourable than extending it beyond the 41- to 60-day standard. A dry period of 21-40 days can be offered to multiparous cows without significant milk losses in the subsequent lactation. Eliminating or shortening the dry period should exclude cows after first calving. It seems that a dry period of 21-40 days can also be offered to high-producing cows (≥ 8000 kg milk) because their milk yield, in relation to cows dried for 41-60 days, was lower by 3.5%. Shortening the dry period has a positive effect on the concentration of basic milk components such as fat and protein, causing them to increase. Dry period length had no effect on milk lactose content.

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