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Factors Affecting the Dry Period Length and Its Effect on Milk Production and Composition in Subsequent Lactation of Holstein Cows

Research Article

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ABSTRACT

The study aimed to determine factors affecting the dry period length and effect of dry days on milk yield, milk composition and lactation length in the next lactation of dairy cows. Data used for analysis included 7264 lactation records collected from 2012 to 2016 on 4737 Holstein cows raised in 152 herds. The statistical model used to determine the factors influencing the dry period length showed that multiparous cows had a dry period 3.7 days longer than primiparous cows, and cows that calved from October to February had a dry period 2.5 days shorter than that of cows calved from March to September. The mixed model used to evaluate the influence of dry period on milk yield, milk composition and lactation length showed that the dry period influenced significantly milk yield and composition in the next 305 d lactation, but not the lactation length (P>0.05). Milk, fat and protein yields in the subsequent lactation were maximized with a 41 to 60-d dry period, whereas dry periods less than 20 d result in very pronounced losses in subsequent lactation yield. Fat and protein percentages were highest with the dry period classes greater than 80-d and less or equal than 20 d, respectively. The interaction between parity and dry length period was not significant (P>0.05) for any studied trait, indicating that dry days effects on milk yield and composition were consistent across lactations. It was concluded that dry period of 40 to 80 dry days does provide maximal performance in Holstein cows.

KEY WORDS dairy cows, dry period, milk composition, milk yield, parity by dry period length interaction.

INTRODUCTION

A dry period before the expected calving is needed for dairy cows to regenerate their mammary gland and to maximize milk production during the next lactation. Numerous studies demonstrated that a 60-d dry period is optimal (Kuhn *et al*. 2005; Hossein-Zadeh and Mohit, 2013; Sawa *et al*. 2013), and a dry period less than 40-d reduces milk yield in the subsequent lactation (Sorensen and Enevoldsen, 1991; Rémond *et al*. 1997; Annen *et al*. 2004; Andersen *et al*. 2005; Rastani *et al*. 2005; Sawa *et al*. 2012). However, during recent years, there has been an interest in shortening or even in omitting the dry period in order to get additional milk yield from extending the lactation. Rémond *et al*. (1997) and Andersen *et al*. (2005) reported that shortening or eliminating the dry period may result in a lower yield while improving fat and protein contents. Van Knegsel *et al*. (2013) found that milk yield after calving decreased by 4.5% for a short dry period (4 to 5 weeks) and by 19.1% for no dry period, whereas protein content of the milk increased by 0.06% for a short dry period and by 0.25% for no dry period. Moreover, compared to cows that had been dry for 40-60 days, the cows whose calving was not preceded by a dry period had lower lacta-

tion yield by 25% for milk, 24% for fat and 20% for protein (Sawa *et al*. 2012). Likewise, Rémond *et al*. (1997), Annen *et al*. (2004), Andersen *et al*. (2005) and Rastani *et al*. (2005) stated that the absence of a dry period reduced the yield of milk and milk nutrients by 18-40%. However, Gulay *et al*. (2003), Grummer and Rastani (2004) and Soleimani *et al*. (2010) reported that the dry period may be shortened without adversely affecting milk yield in the subsequent lactation. Meanwhile, extending the dry period (>70 days) reduced the yield of milk and its components (Kuhn *et al*. 2007), and beyond 100 days might shorten lactations (Sawa *et al*. 2012). Optimal dry period length may vary depending on parity (Dias and Allaire, 1982; Grummer and Rastani, 2004). In primiparous cows, it was found that in terms of milk yield, shortening the dry period is less favorable than extending it beyond the 40-60-day standard.

Eliminating or shortening the dry period should exclude cows after first calving (Sawa *et al*. 2013). On the other hand, shortening the dry period has a positive effect on the concentration of basic milk components such as fat and protein, causing them to increase (Soleimani *et al*. 2010; Sawa *et al*. 2013). Thus, there is substantial debate on the optimum length of the dry period for high milk production in the next lactation.

The aim of this study was to determine factors affecting the dry period length and to investigate the effect of the dry period length on milk performance traits in order to determine the optimal length of the dry period, which promotes advantageous productivity of Holstein cows in Morocco.

MATERIALS AND METHODS

Site of study

Data used in this study were collected in dairy herds of a cooperative located in the South-West of Morocco. The climate in which these herds were located was semiarid and was characterized by a mean annual temperature of 19 ˚C, with the minima mean of the coldest month of 11 ˚C, the maxima mean of the hottest month of 27 ˚C, and the mean annual rainfall of 250 mm, mainly occurring from November to March. The herds evaluated were managed according to the advices under conditions similar to those used in most developed countries.

Data analyzed

Data analyzed were part of the official milk recording applied in the country, which is classified as type A4. During lactation, the milk recording is performed by a trained technician once per month within the interval 22-37 days, where milk yield obtained from each cow at each milking was weighed and a sample of milk was taken from all the daily milking of each cow for composition analyses (milk fat and protein).

Lactations were obtained by the test interval method, as the milk yield average of two consecutive test-days multiplied by the number of days between these two test-days, and adding all periods' yields (International Committee for Animal Recording, 2014). Lactation records were standardized to 305 days, except those of cows that went dry with less than 305 days of milk.

Cows were dried off if the daily milk yield was less than 3 kg or if the yield at one milking was less than 1 kg (International Committee for Animal Recording, 2014). The dry period length was calculated as the number of days between the drying off date and the next calving date, and grouped into 5 classes: ≤ 20, 21-40, 41-60, 61-80, > 80 days.

Data were restricted to records for which the first milk recording had occurred between 5 and 75 days' postpartum, and spacing of consecutive recording days was not longer than 70 days.

Data were edited for errors, redundancy and incomplete observations. After editing, cows with unknown birth or calving date, cows without a lactation number or with a lactation number greater than 3, cows with a lactation length less than 210 days, cows with dry period more than 150-d, and those with milk yield less than 2000 kg or greater than 14000 kg were discarded. Records initiated by abortion were excluded because they could lead to dry periods or lactations of abnormal length. Also, records were also deleted from the analyses if there was no information on one of the studied traits. Each herd was also required to have a minimum of 2 cows at each year; if a herd had fewer than 2 cows in any particular year, the herd-year of calving class was deleted.

Statistical analyses

The data file included a set of 7264 records realized between 2012 and 2016 by 4737 Holstein cows raised in 152 herds. The traits studied were milk, fat and protein yield and fat and protein percentage during 305 days of lactation, besides dry period and lactation length. A summary of the number of records, arithmetic means, standard deviations and coefficients of variation for each trait is presented in Table 1.

Phenotypic correlations among studied traits were calculated by Corr procedure (SAS Institute Inc., Cary, NC, USA) procedure (SAS, 2002). Data were analyzed using Mixed procedure (SAS, 2002). The least-squares means were estimated by restricted maximum likelihood (REML) method.

Table 1 Arithmetic mean, standard deviation and coefficient of variation for 305-d milk, fat and protein yield, fat and protein percentage, dry period and lactation length

Trait	Number of records	Arithmetic mean	Standard deviation	Coefficient of variation (%)
Dry period (days)	7264	49.8	31.2	62.6
Lactation length (days)	7264	347.1	66.7	19.2
Milk yield (kg)	7264	7827.4	1745.5	22.3
Fat yield (kg)	7264	307.0	77.2	25.1
Protein yield (kg)	7264	262.7	71.0	27.0
Fat percentage (g/kg)	7264	39.3	5.04	12.8
Protein percentage (g/kg)	7264	33.4	4.09	12.2

The statistical model used to determine the factors influencing the dry period length included the random effect of cow (4737 cows) and the fixed effect of herd-year of calving (494 levels), which is a combination of herd (152 levels) and year of calving (5 levels: 2012, 2013, …, 2016), season of calving (March-September and October-February) and parity (primiparous *vs.* multiparous), whereas the one used to evaluate the influence of dry period on milk yield and composition and lactation length included the previous effects, in addition to the days dry as a categorical variable (≤20, 21-40, 41-60, 61-80 and >80 days) and the interaction between parity and dry period that was included in the model in order to test the effect of dry period on studied traits of primiparous and multiparous cows. The other interactions between effects were assumed to be negligible and were not tested.

RESULTS AND DISCUSSION

Table 2 shows the phenotypic correlation among studied traits, especially between dry period and subsequent performance of dairy cows. There were significant and negative relationships between dry days and protein yield, fat percentage and protein percentage in Holstein cows (P<0.05); therefore, these three milk constituents might decrease along with the increase in the dry period. Also, there were non-significant negative relationships between dry period on one hand, and milk and fat yield and lactation length of dairy cows. Hossein-Zadeh and Mohit (2013) reported significant and negative correlations (from -0.07 to -0.04) between dry period on one hand, and milk, fat and protein yield, as well as fat and protein percentage on the other hand.

In this study, the dry period averaged 49.8 days (Table 3). This average falls within the range of 6-8 weeks prescribed in breeding practice. The dry period obtained in the current study is lower than the report of Hossein-Zadeh and Mohit (2013) who stated to be 100.5 days for Holstein cows of Iran, indicating that breeders participating in the current study respect the dry period advised by technicians as the necessary period favorable for the high milk production in the next lactation.

Among 7264 dry periods, 32.3% and 35.7% were 21-40 and 41-60 days long, respectively (Figure 1). However, both too short (≤20 days) and too long (>80 days) dry periods were less frequent (9.39% and 10.3%, respectively) than more mid-range dry period lengths. Sawa *et al*. (2012) reported that dry period 40-60 days long represented 39.3%. The dry period length was influenced (P<0.001) by herd-year of calving, parity and calving season (Table 3). Multiparous cows had a dry period 3.7 days longer than primiparous cows. This result is in agreement with the findings of Hossein-Zadeh and Mohit (2013) who reported that primiparous cows had the lowest dry period. Cows that calved from October to February had a dry period 2.5 days shorter than that of cows calved from March to September. Kuhn *et al*. (2007) and Hossein-Zadeh and Mohit (2013) found that summer calved cows had a dry period shorter than that of cows calving in other seasons. Statistical analysis showed that the dry length period influenced milk yield and composition in the next 305-d lactation, but not the lactation length (P>0.05). Moreover, fat and protein yields were very similar and followed the same pattern as for milk yield. Thus, milk, fat and protein yield in the subsequent lactation was maximized with 41-60-d and 61-80-d dry periods, whereas cows within the dry period class ≤ 20-d had the lowest values for these traits (Table 4). Cows with a dry period ≤ 20-d produced 414.0 kg, 17.2 kg and 11.5 kg less milk, fat and protein, respectively than those given a 41-60-d dry period. There were also losses in milk, fat and protein yield associated with long dry periods (>80 days) (126.5 kg, 2.6 kg and 8.5 kg, respectively compared with a 40-60-d dry period), but these losses were not as large as those for the very short dry periods. Thus, the highest milk, fat and protein yield was found for cows that were dried for 40-80 days, indicating that too short as well as too long dry periods have a negative effect on these traits in the subsequent lactation. Moreover, dry periods of 20-d or less were severely and by far the most detrimental. These findings are in agreement with reports of several authors (Kuhn *et al*. 2005; Sawa *et al*. 2012; Sawa *et al*. 2013; Hossein-Zadeh and Mohit, 2013) who found that the most advantageous length of the dry period in terms of milk, fat and protein yield in the forthcoming lactation was 40-60 days.

Table 2 Correlation coefficients among 305-d milk, fat and protein yield, fat and protein percentage, dry period and lactation length

Item	Lactation length	Milk yield	Fat yield	Protein yield	Fat percentage	Protein percentage
Dry period	-0.008^{ns}	-0.021^{ns}	-0.002^{ns}	-0.029*	-0.033*	-0.02**
Lactation length	-	0.380***	0.565***	0.675***	0.425***	0.768***
Milk yield	-	-	0.850***	0.882***	-0.058***	0.143***
Fat yield	-	-	-	0.903***	0.463***	0.434***
Protein yield	-	-	-	-	0.224***	0.583***
Fat percentage	-	-	-	-	-	0.577***

* (P<0.05); ** (P<0.01) and *** (P<0.001).
NS: non significant.

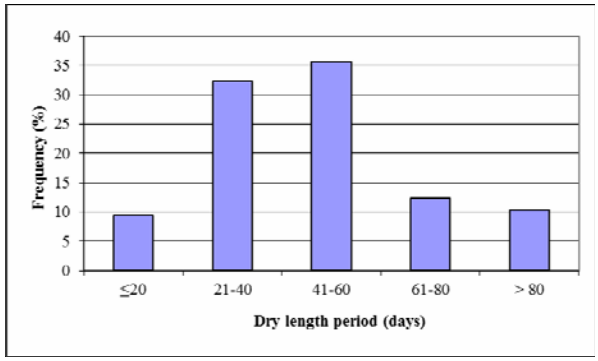

Figure 1 Distribution of dry length period of Holstein cows

They are also consistent with the results of Weglarzy (2009) who showed that too short (<1 month) and too long (>3 months) dry periods adversely affect milk, fat and protein yield in the next lactation. According to Sawa *et al.* (2012), extending the dry period to 61-80 (and even to 81-100) days reduces milk yield to a small extent (by about 1 and 4%, respectively), with greater losses (5%, 14% and 25%) observed when this period was shortened to 21-40 and 1-20 days, or completely omitted. Also, Kuhn *et al.* (2006) advised avoiding dry periods longer than 70 days because of a reduction of milk yield in the subsequent lactation.

Table 3 Least-squares means (LSM) ± standard errors (SE) for dry days period of Holstein cows

Source of variation	Number	LSM±SE
Parity		***
Primiparous	3561	49.0±0.63^{b}
Multiparous	3703	52.7±0.70^{a}
Season of calving		***
March-September	3563	52.1±0.68^{a}
October-February	3701	49.6±0.64^{b}

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
*** (P<0.001).

Milk, fat and protein yield increased, with increasing dry period, at a decreasing rate. Thus, moving from classes ≤ 20-d to 21-40-d, increased milk, fat and protein yield by 280.9 kg, 10.2 kg and 6.5 kg, respectively, but increasing dry period from classes 21-40-d to 41-60-d added only 133.1 kg, 7.0 kg and 5.0 kg of lactational milk, fat and protein yield, respectively (Table 4).

Thus, the increase in milk yield is not linear over the range of 0 to 60-d dry period. Kuhn *et al.* (2005) also found non-linear increases in yield with increasing dry period over this range dry periods. Rémond *et al.* (1997) reported that milk yield increased as dry period increased up to 6 to 7 weeks. Therefore, the milk yield loss in the next lactation of cows with 21-40-d dry periods compared to those with dry periods of 41-60-d was only 133.1 kg (Table 4). This little difference might be easily offset by the additional milk yield gained in the previous lactation as long as cows produced more than 6.65 kg/day during the last 20-d of lactation.

This result implies that the dry period might be shortened to 40 days for high producing cows without affecting the farmer's income. These findings are consistent with those of Kuhn *et al.* (2005) who concluded while the results clearly showed milk yield loss in subsequent lactation for dry periods less than 60-d, dry periods shorter than 60-d may still be useful. Other studies (Bachman and Schairer, 2003; Gulay *et al.* 2003) showed no effect of shortening the dry period from 60 to 30 days for milk yield. Moreover, Rémond *et al.* (1997) concluded that the milk yield loss in the next lactation is inversely related to milk yield during the last weeks of previous pregnancy. They proposed a regression equation (y=51.4x–113) to estimate the milk yield during the last 8 weeks of pregnancy (y, kg) on daily milk yield at the 9th week preceding calving (x, kg/day). In the opposite, Kok *et al.* (2017) stated that previous dry period did not significantly affect the effective lactation yield. Thus, cows can be managed with short or no dry period over consecutive lactations without a change in quantity of milk losses.

In contrast to yields, cows within the dry period class of 0-20 d had the greatest protein percentage, and those within the dry period classes of 61-80 d and greater than 80-d had the highest fat percentage (Table 4). Thus, for too short as well as too long dry periods, milk yield decreased while fat and protein percentage increased. This may be explained, at least for fat percentage, by the negative correlation between this trait and milk yield (Table 2). However, this explanation is not in agreement with the conclusion of Kuhn *et al.* (2006) who stated that the effect of dry period on percentages appears to be independent of effects on milk yield.

Table 4 Effects of the dry period length on 305-d milk, fat and protein yield, fat and protein percentage and lactation length of the subsequent lactation

Dry period (days)	Lactation length (days)	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat percentage (g/kg)	Protein percentage (g/kg)
≤ 20 d	335.7±2.72	7212.8±57.1^{d}	282.7±2.79^{c}	243.4±2.48^{d}	39.2±0.20^{b}	33.5±0.16^{a}
21-40 d	340.9±1.67	7493.7±36.5^{c}	292.9±1.76^{b}	249.9±1.57^{c}	39.1±0.12^{b}	33.1±0.10^{bc}
41-60 d	342.6±1.61	7626.8±35.5^{a}	299.9±1.71^{a}	254.9±1.52^{a}	39.3±0.12^{b}	33.2±0.10^{b}
61-80 d	342.7±2.37	7628.2±50.2^{ab}	299.1±2.45^{a}	251.7±2.18^{ab}	39.3±0.17^{ab}	32.9±0.14^{c}
> 80 d	340.3±2.62	7500.3±55.4^{bc}	297.3±2.70^{ab}	246.3±2.40^{bcd}	39.8±0.19^{a}	32.8±0.16^{c}
P-value	0.1849	< 0.0001	< 0.0001	< 0.0001	0.0167	0.0055

The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Further, the advantage in milk protein percentage decreased as dry period length increased. Thus, cows with ≤ 20-d dry period had 0.07 percentage units higher proteins than cows with > 80-d dry period. This result is consistent with those of several authors (Kuhn *et al*. 2005; Kuhn *et al*. 2006; Soleimani *et al*. 2010; Hossein-Zadeh and Mohit, 2013; Sawa *et al*. 2013) who found an increased milk protein percentage postpartum for cows on the short dry period compared with cows on the traditional dry period of 40-60 d.

Rémond *et al*. (1992) and Rastani *et al*. (2005) also found higher protein percentage for cows with no dry period compared with cows with 60-d dry period. Concerning fat percentage, our results are consistent with those of Gulay *et al*. (2003) who found a 0.06 higher fat percent for 60-d dry period compared with a 30-d dry period treatment during the first 10 weeks of lactation. In contrast to our results, that showed a highest fat percentage for dry periods greater than 80 days, other studies (Kuhn *et al*. 2006; Hossein-Zadeh and Mohit, 2013; Sawa *et al*. 2013) reported that shorter dry periods favor higher fat percentage. Nevertheless, Kuhn *et al*. (2006) concluded that although results for the two percentages were similar, dry period does appear to have a somewhat larger effect on protein content than on fat content. Sawa *et al*. (2013) related these changes in fat and protein content with the milk yield in lactation preceding the dry period, since they observed that 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, whereas in the group of cows which milk yield in the lactation preceding the dry period exceeded 8 000 kg, this tendency did not occur.

The interaction between parity and dry period on the subsequent milk yield and composition of dairy cows was not significant (P>0.05), indicating that days' dry effects on milk yield and constituents were consistent across lactations. This result might be explained by the fact that records analyzed in the present study were restricted to the first three lactations. Our findings are in agreement with Sorensen and Enevoldsen (1991) who found a non-significant interaction dry period and lactation number on milk yield.

The absence of interaction dry period × parity in the current study is not consistent with the findings of Sawa *et al*. (2013) who reported that in primiparous cows, short dry periods were less favorable in terms of milk yield than those extended beyond the 41-60-d standard, and multiparous cows can be assigned a 21-40-day dry period without a significant reduction in milk yield in the subsequent lactation. Likewise, Hossein-Zadeh and Mohit (2013) concluded that even when dry period effects were found to differ slightly across parities, the dry period length to maximize subsequent lactation performance was generally the same regardless of parity. According to Kuhn *et al*. (2005), dry periods shorter than 40 days are more detrimental to primiparous than multiparous cows, which is due to differences in physiological maturity. Moreover, Sawa *et al*. (2015) reported that in the case of multiparous cows, a dry period of 31-50 days can be employed without considerable milk losses in the subsequent lactation.

Lactation length did not vary according to the length of the preceding dry period. This result is not in conformity with that of Sawa *et al*. (2012) who found that the longest lactations (329 days) were those after dry periods of 21-60 days, and lactations were shorter (by as much as 34 days) after the longer or the shorter the preceding dry period.

CONCLUSION

In conclusion, average dry period was 49.8 days in Holstein cows. Herd-year of calving, season of calving and parity had significant effects on the dry period of dairy cows. Primiparous cows had lower dry period than multiparous cows. Fall-winter calved had the shortest dry period. A dry period of 41-80 days was the most favorable in terms of milk, fat and protein yield in the next lactation for both primiparous and multiparous cows. Extending or shortening the standard dry period of 40-60 days causes a decrease in yield. However, shorter dry periods had more undesirable effects than longer dry periods. In contrast to yield, shortening and extending the dry period has a positive effect on protein and fat percentage, respectively, causing them to increase. Finally, there is no evidence for the interaction between dry period and parity, indicating that cows respond similarly to dry period regardless of their parity.

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