The effect of dry period length reduction to 28 days on the performance of multiparous dairy cows in the subsequent lactation

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Pezeshki, A., Mehrzad, J., Ghorbani, G. R., DeSpiegeleer, B., Collier, R. J. and Burvenich, C. 2008. **Effect of dry period length reduction to 28 days on the performance of multiparous dairy cows in the subsequent lactation.** Can. J. Anim. Sci. **88**: 449–456. In a controlled study, the effects of shortened and conventional dry periods (28.2 ± 4.6 vs. 48.8 ± 4 d) on performance of multiparous cow were evaluated. Seventy multiparous Holstein cows were randomly assigned to either a 28- or a 49-d dry period length (DPL). Nine cows were removed from the study and 61 cows were used in the statistical analysis. Cows in the 28-d DPL group were moved to close-up pen and fed only close-up ration during the dry period, whereas those in the 49-d DPL group were given a far-off diet after dry-off until 28 d before expected calving, and then fed the same diet as the cows in the 28-d DPL group. Daily milk yield production was significantly reduced in the 28-d DPL group compared with the 49-d DPL group through 210 d in milk (DIM). Neither milk protein nor milk fat was changed in experimental groups. However, fat yield tended to be greater in the 49 d DPL compared with the 28 d DPL. Cows with 28 d DPL lost less body condition in peripartum and gained more body condition score (BCS) by 150 DIM. No differences were detected in health disorders, reproduction efficiency and birth weights of calves due to shortened dry period. Our data demonstrate that a shortened dry period under employed management practices is a good management tool in attenuating negative energy balance status without adversely affecting total milk production.

Key words: Dry period, management, multiparous dairy cow, performance, body condition score

Pezeshki, A., Mehrzad, J., Ghorbani, G. R., DeSpiegeleer, B., Collier, R. J. et Burvenich, C. 2008. **Conséquences du raccourcissement de la période de tarissement à 28 jours sur le rendement des vaches laitières multipares lors de la lactation subséquente.** Can. J. Anim. Sci. **88**: 449–456. Dans le cadre d'une étude avec témoin, les auteurs ont évalué les répercussions d'une période de tarissement plus courte sur le rendement des vaches multipares, comparativement à la période de tarissement usuelle ($28{,}2 \pm 4{,}6$ c. $48{,}8 \pm 4$ jours). À cette fin, ils ont réparti au hasard 70 vaches Holstein multipares entre une période de tarissement de 28 ou de 49 jours. Neuf vaches ont été retranchées de l'étude et 61 ont servi à l'analyse statistique. Les vaches taries 28 jours ont été placées dans l'enclos de préparation au vêlage et nourries uniquement avec la ration appropriée durant le tarissement; celles du second groupe ont reçu la ration de tarissement jusqu'au 28^{e} jour précédant la date de vêlage prévue, puis la même ration que celles du premier groupe. Le rendement laitier quotidien des vaches du premier groupe était sensiblement plus faible que celui du second pendant la période de lactation de 210 jours. La concentration de protéines et de matière grasse dans le lait était néanmoins la même. Le rendement en matière grasse avait tendance à être plus élevé chez les vaches taries 49 jours. Les vaches taries 28 jours étaient en meilleure forme physique après la parturition et avaient une note d'état corporel plus élevée après 150 jours de lactation. Les auteurs n'ont relevé aucune variation dans l'état de santé, les aptitudes à la reproduction et le poids de naissance des veaux consécutivement au raccourcissement de la période de tarissement. Ces résultats montrent que, dans de bonnes pratiques d'élevage, raccourcir la période de tarissement est un bon moyen d'atténuer le déséquilibre énergétique sans pour autant affecter la production totale de lait.

Mots clés: Tarissement, gestion, vache laitière multipare, rendement, note d'état corporel

Abbreviations: **BCS**, body condition score; **△BCS 1**, changes of BCS from 7 wk prepartum to 60 d in milk; **△BCS 2**, changes of BCS from 60 to 150 d in milk; **DBCS**, BCS at 7 wk prepartum; **DIM**, days in milk; **DPL**, dry period length

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It is well established that a dry period is required to replace senescent mammary epithelial cells and increase the epithelial component of the gland before the next lactation (Capuco et al. 1997, 2003; Annen et al. 2007). Historical studies have shown that an optimal dry period length (DPL) is between 50 and 60 d (Funk et al. 1987; Sorensen and Enevoldsen 1991; Makuza and McDaniel 1996). However, recent studies in the United States have supported the use of shorter dry periods with minimal effects on subsequent milk yields (Gulay et al. 2003; Annen et al. 2004; Rastani et al. 2005). More recently, it has been documented that short dry periods can be applied successfully for multiparous cows rather than primiparous cows (Pezeshki et al. 2007). Apparently, primiparous cows are more sensitive to reduced DPL and, consequently, they do not produce milk as much as multiparous cows submitted to the same short dry periods (Gulay et al. 2003; Annen et al. 2004; Pezeshki et al. 2007). Some studies reported that long dry periods ($>$70 d) have negative effects on milk production in the next lactation (Schaeffer and Henderson 1972; Sorensen and Enevoldsen 1991). Omitting the dry period reduces milk yield with about 11–25% in the next lactation (Smith et al. 1967; Rémond et al. 1992; Rastani et al. 2005), unless somatotropin is used (Annen et al. 2004).

Most of the aforementioned studies on short DPL were retrospective and based on production records that included observational data without any randomized assignment of cows to different DPL. Also, the majority of these studies have been carried out in one region of the world, limiting the universality of the conclusion. Few studies with randomized assignment of cows to different DPL have been conducted (Gulay et al. 2003; Annen et al. 2004; Andersen et al. 2005; Bachman 2002; Gulay et al. 2005; Gůmen et al. 2005; Rastani et al. 2005; Pezeshki et al. 2007). The reproductive status of dairy cows with different DPL has been reported previously (Annen et al. 2004; Gümen et al. 2005), but these authors considered that the number of animals was too small to draw a conclusion.

It has been proposed that a short dry period could be an appropriate management strategy to reduce the frequency of dietary changes during the dry period, potentially leading to optimum energy balance of cows in the subsequent lactation (Grummer and Rastani 2004). To our knowledge, no between-cow study has investigated the influence of dietary change frequencies or feeding management during the dry period on productive efficiency, reproduction and health status of dairy cows subjected to short DPL. Recently, a non-consistent prepartum dietary scheme was employed on the mean of 22 cows for each treatment, regardless of parity, average daily milk production and days in milk (DIM), which was blocked in that study (Rastani et al. 2005), and hence no conclusion on the effects of the frequency of dietary changes on animals' performance could be made.

Thus, the objective of the current study was to evaluate the effect of 28- and 49-d DPL associated with dietary change frequencies on the performance of multiparous lactating dairy cows on a government dairy farm in the northwest of Iran. Introducing a particular feeding management strategy based on DPL manipulation for dairy cows during the dry period was the main aim of this study. Cows assigned to 28-d DPL received only close-up ration or less dietary changes during the dry period, while cows subjected to 49-d DPL received both far-off and close-up rations, so they experienced greater dietary changes.

MATERIALS AND METHODS

Animals, Treatment and Feeding

This study was conducted on a government dairy farm (900 cows) located in Qazvine, Iran, under conditions comparable with those laid down by the Canadian Council on Animal Care. The required number of animals to study parametric traits was calculated for a standard power value of 0.8 (significance level $\alpha = 0.05$) based on previously obtained standard deviations and generally accepted delta values for each trait (Rosner 2005). These calculations resulted in the conclusion that an average of 30 cows for each treatment is the minimum number required for unbiased statistical comparisons. Thus, 70 multiparous Holstein dairy cows were assigned randomly to one of two DPL [i.e, 49 d ($n = 31$) and 28 d ($n = 39$)], approximately 8 wk before expected calving. Cows were selected for this study based on following criteria: (1) the absence of clinical signs of mastitis and an individual somatic cell count $<$250 000 cells mL^{-1}; (2) number of days open $<$200 d, and (3) 3 mo before expected calving date, average milk production was above 20 kg d^{-1}. The study started in April 2004 and continued until December 2004. All cows in both groups calved from Jun. 21 to Aug. 13. A total of nine cows were removed because of incorrect DPL, and health disorders (i.e., foetus absorption, retained placenta, metritis, lameness and diarrhoea) before assigning the cows to treatments (Table 1). As a result, 61 cows were used in the statistical analysis. Cows were dried off through gradual cessation of milking. All cows were checked for mastitis in combination with intramammary dry cow antibiotic treatment (Benzathine Cloxacilin, Kimia Biotechnology co, Arak, Iran). Cows were fed a total mixed ration, three times a day at 0900, 1700 and 0100 (Tables 2 and 3) to meet their requirements for production and pregnancy [National Research Council (NRC) 2001]. All cows had free access to water. Dry cows were housed in two stalls: far-off pen and close up pen (from 49 to 21 d before the expected calving day and 21 d before expected calving to actual calving day, respectively). Cows subjected to a 28-d treatment were transitioned to a close-up dry cow pen and fed a close up ration at the time of milk stasis. After milk cessation, cows in the 49-d

Table 1. Summary of management information of cows with two different dry period lengths (DPL)

DPL[z]			
	49 d	28 d	Item
Cows			
	27	34	Number[y]
	3.1	3.03	Mean Parity[x]
	2–7	2–8	Parity range[w]
	4	5	Removed (*n*)
	22.2	21.1	Dry-off milk yield (kg d^{-1})
			Dry Period (Mean ± SD)
	48.8 ± 4	28.2 ± 4.6	Actual (d)
	42–57	19–37	Range (d)
			DBCS[v]
	2.9 ± 0.7	2.8 ± 0.8	Average DBCS (Mean ± SD)[v]
	1.75 to 3.75	1.75 to 4.25	DBCS range[v]
Foetus absorption (1), retained placenta and metritis (1), laminitis (1), incorrect dry period length (1)		Incorrect dry period length (4), diarrhoea (1)	Reasons for removing cows[u]

[z]Cows subjected to 28-d dry period length (DPL) transferred to close-up pen directly at drying-off time. Cows assigned to 49-d DPL experienced far-off period for 21 d before moving to close-up pen.
[y]Number of cows included in statistical analyses (i.e., excluding the removed cows).
[x]Mean parity of cows at 7 wk before expected calving.
[w]Parity range of cows at 7 wk before expected calving.
[v]DBCS = body condition score (BCS) at 7 wk before expected calving.
[u]Values within parentheses are number of animals removed from the study.

group were transitioned to far-off dry cow pens until 21 d before expected calving date. The cows were then transferred to the close-up pen and fed a close-up ration until calving. Cows assigned to 28-d DPL experienced less dietary change (late lactation-close-up and close-up-early lactation) than cows assigned to 49-d DPL (late lactation-far-off, far-off-close-up and close-up-early lactation). Cows with 28-d DPL had longer lactation than those with 49-d DPL in the previous lactation.

Sample Collection and Analysis

All cows were milked three times per day (at 0800, 1600 and 2400), and milk yield was recorded daily throughout 210 DIM. Milk yield data were adjusted to 305 d. Milk samples (50 mL) were taken weekly at three consecutive milkings until the 10th week of lactation, and were analyzed for fat and total protein. Shortening the dry period extends the lactation for cows with 28-d DPL. This extended lactation for the 28-d DPL group resulted in additional milk production, recorded daily prepartum, compared with 49-d DPL.

Feed samples from far-off, close-up and early lactation diets were collected weekly and stored at −20°C until the day of analysis. Stored feed samples were ground and analyzed for dry matter, crude protein, ether extract, neutral detergent fibre, acid detergent fibre, minerals and ash (Table 3). Net energy for lactation (NE_L) was estimated based on cows weighing 650 kg and 11.5 kg dry matter intake for each cow per day for prepartum rations (NRC 2001). For the postpartum ration, NE_L was estimated based on cows weighing 650 kg and 21.8 kg dry matter intake per day (NRC 2001). Dry matter intake and weight values were used for estimation of the NE_L at the previously identified government farm.

Body condition score (BCS) was recorded at 7 wk before expected calving (DBCS) and thereafter at 60 and 150 DIM using a five-point scale (1 = emaciated cows to 5 = severely over-conditioned cows) (Ferguson et al. 1994) by one evaluator without any knowledge of the previous BCS of each cow.

Eventual health disorders that were checked daily in every cow by the herdsmen were verified by veterinary inspection throughout the entire course of the study. Standard definitions of health disorders were used (Gearhart et al. 1990; Mashek and Beede 2001; Burvenich et al. 2003).

Visual signs of oestrus including viscous vaginal mucus, mounting, restlessness, and increased vocalization were observed every 12 h as am/pm rule (Morton 2004) starting immediately after calving. The voluntary waiting period was 50 d. Rectal palpation was used for confirmation of the pregnancy of cows at 180 DIM. Days open, first service conception rate (%), services per conception, and pregnancy rate (%) were recorded. Pregnancy rate was defined as 1 divided by the number of services multiplied by 100 for eligible cows. After confirming the pregnancy at 180 DIM, the cows' reproductive performance was assessed and included in statistical analyses.

Calves of both two groups (28 and 49 d DPL) were weighed at calving to evaluate the effects of DPL on birth weights.

Statistical Analyses

The PROC MIXED procedure of SAS software (SAS Institute, Inc. 1999) was used to analyze milk yield and milk composition data as a completely randomized design with repeated measures. The model used to analyze milk yield and composition data included the fixed effects of treatment, time, two-way interaction terms of fixed effects, the random effect of cow nested within treatment and the residual error. Previous lactation milk yield of cows was included in statistical analyses as a covariate analyzing all the milk yield data. BCS, BCS changes (△BCS), days open, services per conception and pregnancy rate were analyzed with the PROC MIXED procedure of SAS software (SAS Institute, Inc. 1999). The incidence of health disorders and the percentage of first service conception were analyzed with the PROC GENMOD (SAS Institute, Inc. 1999), with the base of nonparametric statistics and differences determined by chi-square test. Statistical power, defined as the probability of the test for rejection of false null hypothesis, was used to estimate the required number of animal to evaluate milk yield, milk composition and BCS data (Rosner 2005) at a significance level of 0.05. When trends are discussed, $P < 0.05$, was regarded as statistically significant.

RESULTS

Changes in Body Condition Score

Mean DBCS or BCS at dry-off did not differ between cows with 28 and 49 d DPL (2.8 ± 0.8 and 2.9 ± 0.7, respectively). Changes of BCS from 7 wk prepartum to 60 DIM (△BCS 1) was negative for cows in both groups (−0.21 and −0.57 for cows with 28 and 49 d DPL, respectively) and it was different between the two groups ($P = 0.001$). Although changes in BCS from 60 DIM to 150 DIM (△BCS 2) in both groups was positive, these changes were not significant between groups (+0.36 and +0.32 for cows with 28 and 49 d DPL, respectively). Cows' BCS at 150 DIM revealed differences ($P = 0.01$) between the two groups (2.97 ± 0.40 vs. 2.68 ± 0.46 for cows with 28 vs. 49 d DPL, respectively). Thus, shorter DPL improved BCS in the next lactation.

Milk Yield and Composition

Average milk yield of cows from 49 d prepartum through 210 DIM was 7354 vs. 7316 kg for 28 d vs. 49 d DPL and was not different (Table 4). Mean daily milk yield of cows with 28 d DPL was 21.1 kg d^{-1} at prepartum prior to dry-off. Cows in this group produced 422 kg of additional milk yield due to the 21 d extension of the previous lactation compared with cows

Table 2. Ingredients of close-up, far-off and early lactation total mixed ration (TMR) fed Hostein dairy cows

	Diets (% DM)		
Ingredients	Far-off	Close-up	Early lactation
Alfalfa hay	9.74	17.9	20.97
Barley grains	0.85	7.20	10.56
Cotton seed meal	1.84	2.88	4.22
Cotton seed with lint	–	2.40	3.52
Corn grains	–	3.60	5.28
Corn silage	77.98	58.07	43.82
Calcium carbonate	0.12	0.12	0.17
Calcium soap of fatty acids	–	–	0.7
Enzymite	0.24	–	0.7
Fish meal	–	0.48	0.19
Magnesium oxide	0.12	–	–
Rape seed meal	2.45	0.72	1.05
Soybean meal	–	4.32	6.33
Salt	0.12	–	0.17
Sodium bicarbonate	–	–	0.35
Vitamin and mineral premix[z]	0.12	2.28	0.35
Wheat bran	6.38	–	1.05

[z]Vitamin and mineral premix contained 5.5% Mg, 7% K, 11.0% S, 3.0% Zn, 3.0% Mn, 2.0% Fe, 0.5% Cu, 0.025% I, 0.015% Se and 0.004% Co, 680 000 IU vitamin A, 160 000 IU vitamin D and 2000 IU vitamin E.

Table 3. Chemical composition of close-up, far-off and early lactation total mixed ration (TMR) fed Holstein dairy cows

	Diets (% DM)		
Chemical composition[z]	Far-off	Close-up	Early lactation
DM (%)[x]	56.05	70.63	76.95
NE_L (mg kg^{-1})[y]	1.52	1.59	1.69
CP (%)[x]	15.8	18.3	20.4
EE (%)[x]	2.7	2.9	4.2
NDF (%)[x]	47.7	38.3	35.8
ADF (%)[x]	30	25.9	24
Ca (%)	0.62	0.65	0.81
P (%)	0.48	0.40	0.46
K (%)	1.53	1.48	1.48
Mg (%)	0.48	0.24	0.25
S (%)	0.21	0.21	0.23
Na (%)	0.15	0.03	0.31
Cl (%)	0.48	0.27	0.43
Zn (mg kg^{-1})	39.8	32.7	35.9
Cu (mg kg^{-1})	7.7	8.1	8.7
Mn (mg kg^{-1})	57.3	35.5	35.5

[z]Chemical composition analyses of diets were performed by Maksal farm laboratory (Maksal, Qazvine).
[y]Net energy for lactation (NE_L) calculated according to NRC (2001). NE_L values for dry period diets were calculated based on a cow weighing 650 kg and consuming 11.5 kg dry matter per day. This value for early lactation diet was estimated based on a cows weighing 650 kg and average 21.8 kg dry matter intake per day.
[x]CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre; DM, dry matter.

Table 4. Milk yield and milk composition of cows assigned to two dry period lengths (DPL)

DPL Measurements	28 d	49 d	*P* value	SEM[z]
Adjusted milk yield from 49 d prepartum through 210 DIM[y]	7354	7316	0.83	322
Unadjusted milk yield from 49 d prepartum through 210 DIM[y]	7301	7411	0.75	330
Adjusted mean milk yield (kg d^{-1})[x]	32.7	34.6	0.03	0.86
Unadjusted mean milk yield (kg d^{-1})[x]	32.2	35.1	0.01	0.89
Unadjusted total 210-d milk yield (kg)	6932	7316	0.27	350
Adjusted actual 305-d milk yield (kg)	10314	10831	0.34	545
Unadjusted actual 305-d milk yield (kg)	10256	10951	0.25	559
% fat[w]	3.30	3.37	0.55	0.31
Fat yield (kg d^{-1})[w]	1.05	1.16	0.08	0.06
% protein[w]	3.17	3.10	0.22	0.05
Protein yield (kg d^{-1})[w]	1.04	1.07	0.53	0.05

[z]SEM = standard error of means.
[y]Cows with 28-d dry period length (DPL) produced 422 kg additional milk during 21 d extended previous lactation compared with those with 49-d DPL.
[x]Daily milk yields were recorded at three consecutive milking for each cow through 210 d in milk (DIM).
[w]Weekly milk samples (50 mL) through 10 wk of lactation were used for milk composition analyses.

with 49 d DPL. When examining just the subsequent lactation, the average daily milk yield of cows with 28 d DPL was less than that seen in cows with 49 d DPL through 210 DIM (Table 4). Postpartum average daily milk yield was 1.9 kg d^{-1} greater for cows with 49 d DPL compared with those with 28 d DPL (Table 4; $P = 0.03$). However, total milk yield (7316.2 kg vs. 6932.2 kg for 49 d vs. 28 d DPL; $P = 0.27$) through 210 DIM were not different. Similarly, no treatment effect was observed on 305 d actual milk yield of cows between the two groups (Table 4).

No differences were found in postpartum milk fat percentage of cows assigned to 28 or 49 d DPL (Table 4); fat yield (kg d^{-1}), however, tended to be greater in 49 d DPL cows compared with 28 d DPL cows (Table 4; $P = 0.08$). Neither milk protein percentage nor milk protein yield was altered by the experimental treatments.

Health Disorders and Reproduction

We failed to detect difference in the incidence of health events between the two groups (Fig. 1). Two cases of dystocia were recorded for cows with 49 d DPL, whereas no dystocia was recorded for the 28 d DPL group ($P = 0.54$). One case of digestive disease was recorded in the 49 d DPL group and no digestive disease was observed in the 28 d DPL group ($P = 0.88$). There were five cases of abortion for cows with 28 d DPL, but only two cases for cows with 49 d DPL (14.7 and 7.4%, respectively; $P = 0.38$). Similarly, the incidence rate of mastitis (11 vs. 8; $P = 0.81$), metritis (5 vs. 2; $P = 0.38$), lameness (8 vs. 9; $P = 0.39$) and retained placenta (3 vs. 3; $P = 0.76$) was similar between 28 and 49 d DPL groups, respectively. No differences in birth weights of calves were detected (42.5 and 42.2 kg for 28 and 49 d DPL, respectively). No differences in days open, first service conception rate (%), services per conception, and pregnancy rate (%) were detected between the 28 and 49 d DPL (Table 5).

DISCUSSION

As described above, cows with 28 d DPL only received the close-up ration, whereas cows with 49 d DPL were fed both the far-off and close-up rations. As shown in Table 1, the reported DBCS in the present study is lower than the target for most herds. This may have been associated with the higher milk production (>20 kg d^{-1}) of cows in late lactation (Table 1). The differences in ΔBCS 1 and BCS at 150 DIM between the two groups are probably attributed to the reduced nutritional stress associated with fewer dietary changes and lower subsequent early lactation milk production for cows with 28 d DPL. In a previous study (Pezeshki et al. 2007), we demonstrated that postpartum BCS was not affected by three different treatments (35, 42 and 56 d dry period lengths). However, the current study evaluated a shorter DPL of 28 d, which had sufficient numbers for BCS comparative analysis (power 1-β calculated = 0.74, standard deviation = 0.49, delta value = 0.33).

Following the 28-d dry period, the cows produced less milk (32.7 kg d^{-1}) compared with those subjected to the 49 d dry period (34.6 kg d^{-1}). Possible reasons for the reduced milk yield following the shortened DPL may include: (1) endocrine differences (Smith et al. 1967), (2) reduced mammary epithelial cell numbers (Swanson et al. 1967; Capuco et al. 1997), and (3) reduced mammary epithelium function (Swanson et al. 1967; Capuco et al. 1997). It is noteworthy that milk depression in the 28-d DPL occurred for the first 210 DIM and was not apparent by 305 DIM. These results are in accordance with our previous study (Pezeshki et al. 2007). In another study (Gulay et al. 2005), reduced milk production in cows with short dry period was reported in first 80 DIM rather than 80 to 150 DIM or 150 DIM. The lack of detectable difference in 305-d milk yield in this study supports the hypothesis that improved energy

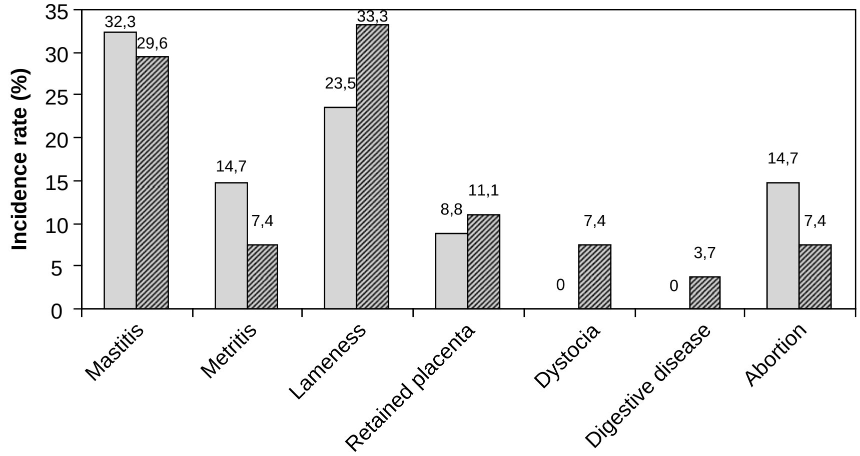

Fig. 1. The incidence rate (%) of some selected health disorders in multiparous Holstein cows subjected to two different dry period lengths (DPL). Experimental groups are 28- and 49-d DPL. Shaded and cross-hatched areas are incidence rate of health disorders in cows with 28- and 49-d DPL, respectively. All studied disorders were checked for every cow by farm personnel and verified by herd veterinarians throughout the study. There are no differences between treatments (28 and 49 d DPL) for health disorders incidence.

status of animals may overcome any differences in secretory function as the lactation progresses. Our data support the hypothesis that shortening the dry period would leave fewer differentiated secretory cells in the mammary glands of dairy cows around parturition. However, more controlled studies are warranted to examine cellular mechanisms that are involved in this process. Negative effects of short dry periods on milk production have been reported by others (Funk et al. 1987; Sorensen and Enevoldsen 1991; Makuza and McDaniel 1996). Nevertheless, a majority of earlier studies adopting short dry periods that resulted in subsequent milk production loss were based on retrospective analyses of observational data. In the current study, only multiparous cows were used to avoid the negative effects of a short dry period on primiparous animals (Annen et al. 2004; Pezeshki et al. 2007) and also to improve the statistical power of the comparisons.

Table 5. The effects of dry period length (DPL) on reproductive status of Holstein dairy cows[z]

	DPL			
Variable	28 d	49 d	*P* values	SEM[x]
Days open	81.2	91.4	0.27	9.13
First service conception rate (%)	41.1	37	0.74	–
Services per conception	1.82	2.07	0.30	0.24
Pregnancy rate (%)[y]	66.91	62.34	0.55	7.65

[z]Studied reproductive parameters were recorded after pregnancy attestation by palpation at 180 d in milk (DIM).
[y]Pregnancy rate defined as 1 divided by the number of services and multiplied by 100 for eligible cows.
[x]Standard error of means.

Previous studies (Gulay et al. 2003; Annen et al. 2004; Rastani et al. 2005) reported that cows with 30 d DPL produced an additional milk yield of about 510 kg during the additional 30 d of lactation due to shortening the dry period. In the present study, 422 additional kg of milk were produced during the 21 d before dry-off time, which offsets the subsequent milk loss of the 28-d DPL. As indicated, even though the shorter dry period (28 d) resulted in reduced initial milk yield, the additional milk during the 21-d longer lactation in the previous lactation reduced overall milk loss during the subsequent lactation. Also, as the lactation progressed those initial differences were compensated. This could be associated with improved energy balance and body condition and possibly improved function of mammary secretory cells as the lactation progressed.

Neither milk fat percentage nor milk fat content was different between the two DPL treatments (Table 4). Similarly, other studies have demonstrated no effect of shortened dry period on milk fat contents (Annen et al. 2004; Rastani et al. 2005; Pezeshki et al. 2007) or on milk fat percentage (Rastani et al. 2005). Depressed level of milk fat yield for cows with 28 d DPL in comparison with those with 49 d DPL was reported in another study (Sorensen and Enevoldsen 1991).

Similar to our results, a previous study (Gulay et al. 2003) did not observe differences between 30- and 60-d dry period for milk protein percentage. While greater milk protein content for 49-d compared with 28-d dry period was reported previously (Sorensen and Enevoldsen 1991), others (Annen et al. 2004) reported greater concentrations of milk protein in milk from cows given a 30-d compared with a 60-d dry period. Recently, we demonstrated that shortening the dry period induced decreased milk protein yield (Annen et al. 2004). The discrepancies in milk composition changes from shortening the dry period may have been resulted from different nutritional management strategies and genetic merit of cows for milk production, or a combination of any or both of these factors.

No differences were detected in calf birth weight (42.5 and 42.2 kg) for the 28- and 49-d DPL groups, respectively. Similarly, others reported no differences between cows with 30- and 60-d dry periods for birth weight of calves (Gulay et al. 2003).

Previously, no differences in days open, pregnancy rate, and services per conception were reported between the 30- and 60-d dry period groups (Lotan and Alder 1976). However, the number of animals for each group was a limiting factor for statistical analysis in that study ($n=9$). Further, other studies reported the binomial reproductive measurements with insufficient statistical power (Annen et al. 2004; Gǔmen et al. 2005). Recently, Watters et al. (2006) demonstrated fewer days open and greater pregnancy rate in cows with shorter dry periods. A previous report (Enevoldsen and Sørensen 1992) was unable to demonstrate any effect of shortening the DPL on some typical metabolic disorders, which is similar to our results.

In conclusion, a 28-d dry period associated with fewer dietary changes had no negative effect on 305-d actual milk yield, health status, reproductive efficiency of the multiparous dairy cows or on birth weights of calves compared with a standard dry period (49 d). Importantly, cows with 28-d DPL tended to be less productive at 210 DIM, but this difference was not apparent across the whole lactation. The additional milk (about 422 kg) produced during the extra 21 d in the previous lactation for the 28 d DPL compared with the 49 d DPL added additional value to the short dry period management scheme. Based on total milk production and improved BCS at 150 DIM, a 28-d dry period was beneficial in decreasing negative energy balance in the subsequent lactation, irrespective of management facilities for the shorter dry period. More full-lactation studies are needed to better evaluate the effects of short dry periods in conjunction with other dry period management practices on milk production, calf health, colostrum quality and mammary gland involution.

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