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Original Research

Retrospective Investigation of The Association Between the Length of Dry Period and Lactation Milk Production and Lifetime Traits During the Subsequent Lactations

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Abstract

A total of 5844 normal lactation records on 1483 Holstein-Friesian cows were collected from El-Alamiah dairy farm in Egypt through the period from 1996 to 2018 to study the effect of the length of dry period on the subsequent lactation performance by evaluating the performance of milk production traits, lifetime traits and some welfare factors of Holstein-Friesian cows, raised in Egypt, to determine the best length of dry period. The milk production traits studied were total milk yield (TMY, kg), 305 days milk yield (305-d MY, kg) and lactation length (LL, day). The lifetime performance traits under study were complete lactation number (CLN, no.), productive life length (PL, month), longevity length (Lon, month), lifetime total milk yield (LTY, kg) and lifetime daily milk yield (LDY, kg). Welfare factors studied were mastitis and lameness scores. TMY, 305 d-MY and LL tended to increase with increasing DP length up to 90 d then decreased thereafter. While the lowest TMY and 305 d-MY (6470.76 and 5435.25 kg, respectively) and the shortest LL (305.81 d) were obtained when DP was below 31. Cows had DP category of 61 to 75d produced the largest amount of milk (34506.39 kg) in a longest Lon and PL (90.56 and 62.65 mo., respectively) and attained the biggest number of CLN (4.474 lactations). All lifetime traits tended to increase with increasing DP up to 61 to 75d then decreased thereafter. The 61 to 75 d DP had the largest mastitis number (0.3532), while DP category of 76 to 90d was associated with the highest lameness number (0.7976). However, no trends were observed in these traits with different DP length categories. The correlation coefficients between DP and all productive traits were significantly negative and ranged between -0.064 to -0.038. DP had no significant correlations with the health traits. Generally, the dry period of 61-75 days is the most optimum for Holstein Cows raised under subtropical warm climate. However, more studies to confirm these results under the Egyptian conditions are required.

KEYWORDS
Dry period, Lactation performance, Lifetime, Heritability, Breeding value.

INTRODUCTION

High-producing dairy cows suffer from conspicuous metabolic strain imposed when transferring from drying to lactating status after parturition, in which cows demand sufficient nutrition for Galactopoiesis. In addition, the drying-off processes especially for high milk yielders inclines the risk of metabolic disorders and mastitis infection. The dry period refers to a time span of 6 to 8 weeks before parturition during which cows are not producing milk (Kok *et al*., 2019). The dry period has many benefits, the main of them is to allow cows that suffer from persistent subclinical mastitis (Bradley and Green, 2001) and treated with antibiotics to have a rest period before parturition, that is associated with the onset of new lactation (Kok *et al*., 2017), besides boosting milk yield in the next lactation. Moreover, the dry period permits to regenerate the senescent mammary epithelial cells (MEC) rapidly during late gestation, at a faster rate than cows would continue milking up to parturition (Capuco *et al*., 1997). Subsequently, a huge number of renewed mammary cells manifest at the moment of delivery which elucidates the high peak milk production in the next lactation after that period (Kuhn and Hutchison, 2005; Van Knegsel *et al*., 2013).

Therefore, the objective of the current study was to investigate the effectiveness of dry period length on the lactation performance of Holstein-Friesian cows, raised in Egypt, and to determine the optimal dry period length not only based on milk yield but also on lifetime performance and some welfare traits.

MATERIALS AND METHODS

A total of 5844 normal lactation records on 1483 Holstein-Friesian cows were collected from El-Alamiah dairy farm, Egypt. Records of dry period (DP) on Holstein-Friesian cows covering the period from 1996 to 2018 were used in the present study. Milk yield was measured weekly on a fixed test day. A cow stopped milking when its daily yield dropped below 10 kg of milk. Dry period was then calculated.

Animal Management

The cows were fed according to NRC (1989) depending on their body weight and level of milk yield and milk fat percentage.

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Water was supplied ad libitum. Cows were grouped according to their milk production level and reproductive status. These groups were independently housed free in open half-shaded yards. Besides, the cows were machine milked twice daily in a milking parlor. Dairy comp 305 recording program was used, and milk yield was recorded for individual cows once or twice a week depending on their production and reproduction status. All cows were veterinary consulted for expected diseases and parasites.

Factors and traits under Study

To describe the effect of DP length on the subsequent lactations' performance, dry period was classified into 6 categories: ≤ 30 (295 records), 31-45 (832 records), 46-60 (2438 records), 61-75 (716 records), 76-90 (457 records) and >90 d (1106 records). The lactation performance traits under study were milk production traits, lifetime traits and health traits. The milk production traits studied were total milk yield (TMY, kg), 305 days milk yield (305-d MY, kg), lactation length (LL, day) and length of dry period (DP, day). The lifetime performance traits under study were complete lactation number (CLN, no.), productive life length (PL, month) defined as number of months from first calving to culling date, longevity length (Lon, month) measured as number of months from birth to culling, lifetime total milk yield (LTY, kg) estimated as total milk a cow produced in her lifetime and lifetime daily milk yield (LDY, kg) calculated from dividing the lifetime total milk yield by the longevity length in days. The health traits were mastitis and lameness scores which were the percentage of months of lactation during which the cows had mastitis or lameness once or many times. The range of possible scores was from zero to 100% (Young *et al*., 1960).

Statistical analysis

Data were analyzed using linear mixed or linear Fixed Models least squares analyses with unequal subclass numbers of PROC GLM procedure of SAS (SAS, 2009). Also, Duncan's test was used for comparing means of each factor.

Also, simple correlations between DP length and all studied traits were calculated. If the correlation coefficient was significant, the simple regression was calculated.

Estimates of heritability and breeding values for dry period was estimated using Multiple Traits Derivative Free Restricted Maximum Likelihood (MTDFREML) according to Boldman *et al.* (1995) using an Animal Model. The mixed Model Equations (MME) for the Best Linear Unbiased Estimate (BLUE) to estimate Function for the (BLUP) was as follows:

$$\begin{bmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z+A^{-1}\alpha_1 & Z'W \\ W'X & W'Z & W'W+I\alpha_2 \end{bmatrix} \begin{bmatrix} b' \\ \mathbf{a}' \\ Pe \end{bmatrix} = \begin{bmatrix} Xy' \\ Zy' \\ Wy' \end{bmatrix}$$

Where, $\alpha1 = \sigma2e / \sigma2a$ and $\alpha2 = \sigma2e / \sigma2p$ and X, W and Z are incidence matrices, and to estimate the heritability, the following equation was used:

$h2 = \sigma2a / (\sigma2a + \sigma2pe + \sigma2e)$

Where, σ2a = additive genetic variance,

σ2pe = permanent environmental variance and

σ2e = the random residual effect.

The standard error of heritability was calculated according to Becker (1984).

RESULTS

Effect of Dry Period on productive traits

Least squares means of productive traits for categories of DP are shown in Table 1. Traits of, TMY, 305 d-MY and LL tended to increase with increasing DP length up to 90 d then decreased thereafter. The category of DP 76-90 d realized the highest TMY, 305 d-MY (7806.29 and 6197.82 kg, respectively) and the longest LL (333.83 d), while the lowest TMY and 305 d-MY (6470.76 and 5435.25 kg, respectively) and the shortest LL (305.81 d) were obtained when DP was below 31.

Table 1. Least squares means of productive traits of the studied dry period (DP) categories

DP category, d	TMY, kg	305d-MY, kg	LL, d
< 31	6470.76^{b}	5435.25^{d}	305.81^{c}
31-45	7595.18^{a}	6188.28^{ab}	315.54^{bc}
46-60	7762.52^{a}	6195.88^{a}	326.02^{ab}
61-75	7610.30^{a}	6094.86^{b}	315.32^{bc}
76-90	7806.29^{a}	6197.82^{a}	333.83^{a}
> 90	7017.13^{b}	5706.83^{c}	306.52^{c}
SEM	489.27	318.6	16.35

$^{a-d}$ means with different letters in the same column are significantly different (P<0.05)

Effect of Dry Period on lifetime traits

Least squares means of lifetime traits for categories of DP are presented in Table 2. Cows having DP category of 61 to 75d produced the largest amount of milk (34506.39 kg) in a longest Lon and PL (90.56 and 62.65 mo., respectively) and attained the biggest number of CLN (4.474 lactations) followed by DP category of 76 to 90d which achieved 32734.59 kg, 89.49 mo., 61.58 mo. and 4.203 for LTY, Lon, PL and CLN, respectively. Similarly, the largest LDY (12.77 kg/d) was obtained for cows having DP category of 61 to 75d followed by category of 46 to 60d (12.51 kg/d). In contrast, DP category below 31d showed the worst lifetime performance for all studied traits except LDY which was the smallest (10.82 kg/d) for DP below 90d. All lifetime traits tended to increase with increasing DP up to 61 to 75d then decreased thereafter.

Table 2. Least square means of mastitis and lameness causalities occurring in the studied dry period (DP) categories.

DP category, d	Mastitis		lameness	
	Number	Score	number	score
< 31	0.07	0.00	0.15	0.00
31-45	0.34	0.01	0.52	0.01
46-60	0.29	0.00	0.65	0.01
61-75	0.35	0.00	0.79	0.01
76-90	0.27	0.00	0.80	0.01
> 90	0.20	0.00	0.68	0.01
SEM	0.21	0.00	0.25	0.00

Effect of Dry Period on welfare traits

Least squares means of health status for categories of DP are illustrated in Table 3. The 61 to 75 d DP had the largest mastitis number (0.3532) and that below 31 d had the lowest (0.0733), but no differences among DP categories were obtained. While DP category of 76 to 90d was associated the highest lameness number (0.7976), but DP over 90 d attained the highest lameness score (0.0104) but without significant differences among DP categories means. However, no trends were observed in these traits with different DP length categories.

Table 3. Least squares means of lifetime traits of the studied dry period DP categories

DP category, d	PL, mo.	CLN, no	Lon, mo.	LTY, kg	LDY, kg/d
< 31	47.72[c]	3.602[c]	75.65[d]	27221.89[d]	11.09[c]
31-45	54.77[b]	4.003[b]	82.71[c]	31026.13[b]	12.13[ab]
46-60	55.30[b]	4.102[b]	83.21[b]	31952.53[b]	12.51[a]
61-75	62.65[a]	4.474[a]	90.56[a]	34506.39[a]	12.77[a]
76-90	61.58[a]	4.203[ab]	89.49[a]	32734.59[b]	12.02[b]
> 90	55.37[b]	3.696[c]	83.29[b]	28438.67[c]	10.82[d]
SEM	4.54	0.30	4.54	2520.71	0.68

[a-d] means with different letters in the same column are significantly different (P<0.05)

Relationships between Dry Period and subsequent lactation traits Correlation coefficients

Table 4 demonstrates the correlation coefficients between DP length and studied productive, lifetime traits and health traits. The correlation coefficients between DP and all productive traits were significantly negative, ranging between -0.064 and -0.038. DP had a positive significant correlation with PL, Lon and LTY but not with CLN and LDY. No significant relationship was found between DP and health traits.

Table 4. Relationships between dry period (DP) length and some productive, lifetime and health traits.

Traits	Correlation		Regression	
	r	Significance	a	b ± SE
Productive traits				
Total milk yield, kg	-0.06	***	7905.06	-4.43±1.7*
305d milk yield, kg	-0.06	***	6207.01	-5.35±1.1**
Lactation length, d	-0.04	***	384.02	0.03±0.1 ns
Lifetime traits				
Productive life, mo.	0.10	***	79.03	0.048±0.03 ns
Complete lactation number, no	0.00	ns	4.01	0.0001±0.000 ns
Longevity, mo.	0.09	***	91.12	0.066±0.019 ns
Lifetime milk yield, kg	0.10	***	27499	-35.26 ±16.91*
Lifetime daily milk yield, kg	0.04	ns	10.91	-0.018±0.0001**
Health traits				
Mastitis, no	0.00	ns	-	-
Mastitis Score	-0.01	ns	-	-
Lameness, no	-0.03	ns	-	-
Lameness Score	-0.04	ns	-	-

*Significant at (P<0.05), ** Significant at (P<0.01), *** Significant a P<0.001, ns not significant

Regression coefficients

Regression coefficients of the studied productive, lifetime and welfare traits on DP length are presented in Table 4. The regression coefficients of each of TMY, 305dMY, LTY and LDY on DP were negative (P < 0.05) being -4.4, -5.35, -35.26 and -0.018 kg, respectively, indicating that increasing DP will decrease milk yield of the lactating cows under study.

Heritability and Breeding value of Dry Period

Heritability and breeding value estimates are presented in Table 5. It could be observed that, DP had a moderate heritability estimate of 0.23. Also, breeding values had wide range of estimates for cows compared to dams or sires. Breeding values ranged from -6.356 to 30.893, -3.663 to 18.965 and -2.681 to 15.556 for cows, dams and sires respectively. Heritability is considered an important approach in the field of animal breeding to be used for planning breeding programmes, estimating breeding values, determining management strategies and for prediction of response for selection.

Table 5. Heritability and Breeding value estimates of dry period for Holstein cows.

Parameters	Value
Heritability	0.23
Breeding values	
Cow	-6.356: 30.893
Dam	-3.663: 18.965
Sire	-2.681: 15.556

DISCUSSION

The presented results concluded that DP category 76-90 d realized the highest milk production performance per lactation. Rashad *et al.* (2019) recorded that dry period of 64-77 days had the longest length of productive life (P<0.001) and the largest number of complete lactations, total lifetime milk yield and lifetime daily milk yield of Holstein cows under Egyptian conditions, and this result is agreement with those of the current study. Kuhn *et al.* (2006) found that the DP category of 91-100 d was the most optimum for the first and second lactations to achieve the highest milk yield. The current results agree with those reported by Węglarzy (2009) showing that the most advantageous DP for milk yield was between 61 and 90 d. Pinedo *et al.* (2011) observed that DP of 53 to 76 d had the highest 305d-MY compared to other categories. Kuhn *et al.* (2006) found that LTY was the maximum for DP 40 to 50d after the first lactation and for DP 30 to 40d after the second and later lactations. The same authors observed that DP was shorter than 30 d or longer than 70 d were costly to LTY and should be avoided.

As recorded in the present study, Safa *et al.* (2013) reported that DP had no effect on health status, especially mastitis infection. Also, Watters *et al.* (2008) showed that shortening DP to 34 d had not affected the incidence of mastitis in the previous lactation due to short LL. Rastani *et al.* (2005) reported a tendency for low somatic cell score by decreasing DP from 56 to 28 d. However, Pinedo *et al.* (2011) observed that extending DP from 143 to 250 d was related to increased odds of subclinical mastitis. In contrast, short DP had a negative effect on SCS in Friesian cows (Kuhn *et al.*, 2006).

Several investigations reported that DP is crucial for involution of the mammary gland and, consequently, maximisation of the milk yield in the subsequent lactation (Coppock *et al.*, 1974; Hurley, 1989; Rastani *et al.*, 2005; Cameron *et al.*, 2015). For most dairy farms, 51- to 60-d has been a steady management practice (Bachman and Schairer, 2003). It has long been understood that reducing DP below 40d reduces milk production (Swanson, 1965, Wheelock *et al.*, 1965; Coppock *et al.*, 1974). DP longer than 60d may raise costs and decrease the longevity of dairy cows (Hurley, 1989). Additionally, Kuhn and Hutchison (2005) found that DP of 60 d maximised TMY in the subsequent lactation, regardless of parity. Also, DP longer than 70 or 80 d resulted in milk yield reduction in previous lactation due to shortened lactation.

In this regard, Coppock *et al*. 1974 observed a decrease in TMY during the subsequent lactation in cows having DP < 40d. When the cow reaches the stage of 35d pre-partum under a DP of 60d, mammary glands epithelial cells become characterized with lack of secretary vesicles in a case known as "a non-secretory state". While, at 7 d pre-partum, 62% of mammary epithelial cells demonstrated secretory activity under 0d DP, whilst 98% of the epithelial cells had secretory activity when DP= 60d. However, Węglarzy (2009) reported that DP shorter than 30 d. or longer than 90 d had a negative effect on 305d-MY.

Negative correlations were found between DP with TMY in the present findings were in accordance with that obtained by Hossein-Zadeh and Mohit (2013) who reported a negative correlation between DP and TMY in Holstein cows. On the contrary, found an increase in TMY with increasing DP. Also, Sawa *et al*. (2012) reported that the correlation coefficient between DP and LL or TMY was 0.02.

Mansfeld *et al*. (2012) wrote that, the risk of mastitis increases when cows with daily milk yield >12.5kg are dried off, which is often the case when the DP is set to 55-60 days. This is agreement with what reported in this study that the cows had 61 to 75 d DP had the largest mastitis number and that below 31 d had the lowest. In contrast, Coppock *et al*. (1974) recorded that, common disorders and udder edema at parturition were not associated with the length of the preceding dry period. But O'Hara (2019) wrote in his theses that the drying-off procedure increases the risk of mastitis and metabolic problems. A dry period of approximately 8 weeks is generally recommended, but a shorter dry period might reduce the metabolic strain on high-yielding cows at dry-off and in early lactation.

CONCLUSION

The dry period has a significant effect on the lactation performance of Holstein-Friesian cows raised in Egypt, whether positively or negatively effect. This study has been proven that the best dry period was 61-75 days, which is the most optimum for Holstein cows raised under subtropical warm climate. However, more studies to confirm these results under the Egyptian conditions are required.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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