

Effects of Milking Frequency on Milk Production and Composition of Holstein Cows during Their First Three Lactations

Research Article

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ABSTRACT

The objective of this study was to investigate the effect of milking frequency (two times daily vs. three times daily) on the 305-d lactation milk, fat and protein yield and fat and protein percentage of Holstein dairy cows in Morocco. Data analyzed were 31400 records collected between 2009 and 2016 on 14272 cows raised in 194 herds. The frequency of milking had significant effects ($P < 0.05$) on 305-d milk, fat and protein yield as well as fat percentage. The milk, fat and protein yield and fat percentage were higher by 265.1 kg, 13.3 kg, 5.8 kg, and 0.3 g/kg, respectively, i.e. 3.79%, 4.78%, 2.40%, and 0.75%, respectively, for cows milked thrice than those milked twice daily. However, the frequency of milking did not influence protein percentage ($P > 0.05$). The interaction between parity and milking frequency was not significant ($P > 0.05$) for any studied trait. Based on the results of this study, it can be concluded that increasing milking frequency increased milk, fat and protein yield as well as fat percentage regardless of parity. However, the additional milk yield obtained might not compensate for the cost of the labor generated by the extra milking.

KEY WORDS dairy cows, milk yield, milk composition, milking frequency, parity and milking frequency interaction.

INTRODUCTION

The increase of milk production costs and the stabilization of milk prices during the last two decades in Morocco forced the dairy farmers to look for efficient management practices for improving their income. Thus, besides the improvements in feeding, genetics, reproduction, health care and housing, increasing milking frequency, from two to three times daily, has been used as an effective tool of increasing milk production. Effect of milking frequency on milk yield has been studied by several researchers around the world, and numerous reports showed that milking cows three times daily increased production by an average of about 15% relative to milking cows twice daily (Amos *et al.* 1985; Barnes *et al.* 1990; Atashi, 2015). The primary

causes of this increase are reduction of intra-mammary pressure and proliferation of mammary gland cells from more frequent milk removal (Czerniawska-Piatkowska *et al.* 2012). Moreover, cows milked three times daily have shown significantly decreased milk fat percentage compared with those milked two times daily (Szuchs *et al.* 1986; Sapru *et al.* 1997; Smith *et al.* 2002), however, milk fat yield (Barnes *et al.* 1990) and protein percentage (Szuchs *et al.* 1986) were unaffected. Further, some studies (Amos *et al.* 1985; Barnes *et al.* 1990; Atashi, 2015) demonstrated that the effect of increased milking frequency on milk yield is more important in first parity cows than in older cows, others (Poole, 1982; DePeters *et al.* 1985; Bortacki *et al.* 2017) showed that multiparous cows respond better to frequent milking than primiparous cows, whereas

some others (Wall and McFadden, 2008) reported that there is no relationship between parity and the magnitude of the milk yield response to frequent milking. Furthermore, some studies reported that the increase of milking frequency affected cows at the beginning of the lactation (Soberon *et al.* 2011; Atashi, 2015; Bortacki *et al.* 2017), but did not have any effect at the end of the lactation.

The objective of this study was to evaluate the effect of milking frequency on milk production and composition across several commercial dairy farms under semiarid conditions of Morocco.

MATERIALS AND METHODS

Site of study

Data used in this study were collected from Holstein cows raised in 194 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 minimal mean of the coldest month of 11 °C, the maximal 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 of the 2 or 3 milking was weighed, and a sample of milk was taken from all the daily milking for composition analyses (milk fat and protein). Lactations were obtained by the test interval method, as the milk yield average of two recordings multiplied by the number of days between the two recordings, 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 in milk. Average cows' age at calving was 40.4 months, ranging from 21 to 68 months, and their average lactation number was 1.84, ranging from 1 to 3.

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, those with milk

yield less than 2000 kg or greater than 14000 kg and cows with a lactation number that did not correspond to a minimum age at calving were discarded. The defined minimum and maximum ages for calving 1, 2, and 3 were determined after the analysis of the frequency distribution of the ages at different calving times. These ages were 21-38, 34-52, and 46-68 months, respectively. Although 85% of herds in Morocco have less than five cows, in this study herds with less than 5 records were discarded.

Statistical analyses

The data file included a set of 31400 records for 305-d milk yield realized between 2009 and 2016 by 14272 cows with complete lactation raised in 194 herds. The traits studied were milk, fat and protein yield and fat and protein percentage during 305 days of lactation. A summary of the number of records, arithmetic means, standard deviations and coefficients of variation for each trait is presented in Table 1. Data were analyzed by least-square analysis of variance using general linear method (GLM) procedure (SAS, 2002). The statistical model accounted for fixed effects of milking frequency (2 and 3 times/day), herd (194 herds), parity (primiparous= first lactation vs. multiparous= second and third lactation), age at calving (age≤24, age≤36, age≤48, age>48), season of calving (March-September and October-February) and year of calving (2009, 2010, ..., 2016). First order interactions between effects were assumed to be negligible and were not tested, except the interaction between lactation number and milking frequency that was included in the model in order to test the effect of milking frequency on studied traits of primiparous and multiparous cows.

RESULTS AND DISCUSSION

Cows milked two or three times per day represented 88.1% and 11.9%, respectively, and the mean milking frequency of all cows was 2.12. Cows of all parities milked three times per day yielded significantly ($P<0.001$) more milk than those milked two times per day (Table 2). The 305-d milk yield was higher by 265.1 kg, *i.e.* 3.79%, for cows milked thrice daily than those milked twice daily. The effect of increased milking frequency on milk yield is in agreement with several authors (Barnes *et al.* 1990; Smith *et al.* 2002; Hale *et al.* 2003; Van Baale *et al.* 2005; Patton *et al.* 2006; Eslamizad *et al.* 2010; Soberon *et al.* 2011; Hart *et al.* 2013; Atashi, 2015), who reported without exception that milking cows three times daily increased milk production per lactation.

However, the milk yield response found in the present study is lower than those reported by the majority of authors. Szuchs *et al.* (1986) found that Holsteins receiving 3 times yielded 12% more milk than those milked twice daily (6992 vs. 6228 kg).

Table 1 Number of records, arithmetic mean, standard deviation and coefficient of variation for milk, fat and protein yield and fat and protein percentage

Trait	Number of records	Arithmetic mean	Standard variation	Coefficient of variation (%)
Milk yield (kg)	31400	7595.4	1519.0	20.0
Fat yield (kg)	23635	300.7	72.4	24.1
Protein yield (kg)	24427	266.7	68.9	25.8
Fat percentage (g/kg)	23677	39.6	4.85	12.2
Protein percentage (g/kg)	24448	34.6	5.10	14.7

Amos *et al.* (1985) and Barnes *et al.* (1990) reviewed several reports and found that milking cows three times daily increased milk yield with an extremely variable response, which has ranged from 3 to 26%. According to Campos *et al.* (1994), the primary causes of increased milk yield are reduction of intra-mammary pressure from more frequent milk removal and reduction in the inhibitory effects that certain milk components exert within milk cells.

Cows milked three times daily have shown significantly increased milk fat and protein yields compared with those milked two times daily (Table 2). The difference in 305-d fat and protein yields was 13.3 kg and 5.8 kg, respectively, *i.e.* 4.78% and 2.40%, respectively. Erdman and Varner (1995) compiled data from 19 studies and concluded that cows milked thrice daily yielded an additional 92 g/d of fat, and 82 g/d of protein compared with those milked twice daily, which are higher than values found in the present study. However, Barnes *et al.* (1990) found that milk fat yield is not affected by milking frequency. Milking cows three times per day increased milk fat percentage ($P < 0.05$) by 0.75% compared with those milked two times per day, but did not affect milk protein percentage ($P > 0.05$)

(Table 2).

The first result is similar to that of Bortacki *et al.* (2017) who noticed an increase in milk fat content of 0.76% after shifting to a three times a day milking schedule. Also, the absence of increased milking frequency effect on protein percentage is in agreement with the result of Szuchs *et al.* (1986). However, with regard to milk fat percentage, our result is different from that of these authors since the latter's found that Holsteins milked thrice per day had a lower fat percentage (3.6 vs. 3.8%) than those milked twice per day. Furthermore, Barnes *et al.* (1990) found that cows milked three times per day have shown significantly decreased milk fat percentage compared with those milked twice daily, whereas Amos *et al.* (1985) reported that percentage total solids or individual components (protein, milk fat, lactose, and ash) were not influenced by milking frequency. The interaction between parity and milking frequency was not significant ($P > 0.05$) for all studied traits (Table 3). These results are similar to those of Wall and McFadden (2008) who found that there is no relationship between parity and the magnitude of the milk yield response to frequent milking.

Table 2 Least-square means and standard errors for milk, fat and protein yield and fat and protein percentage of cows milked twice or thrice per day

Milking frequency	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat percentage (g/kg)	Protein percentage (g/kg)
Cows milked twice per day	6991.5±25.7	278.5±1.53	242.1±1.14	40.1±0.10	34.3±0.08
Cows milked thrice per day	7256.6±43.2	291.8±2.45	247.9±2.25	40.4±0.16	34.2±0.17
Probability	< 0.0001	< 0.0001	0.0068	0.0294	0.5246

Table 3 Least-square means and standard errors for milk, fat and protein yield and fat and protein percentage according to parity and milking frequency

Parity × frequency	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat percentage (g/kg)	Protein percentage (g/kg)
Primiparous milked twice per day	7019.4±36.4	280.3±2.08	246.0±1.74	40.3±0.14	34.7±0.13
Primiparous milked thrice per day	7327.6±58.7	295.0±3.29	253.7±3.12	40.6±0.22	34.6±0.23
Multiparous milked twice per day	6963.6±35.5	276.7±2.03	238.3±1.71	40.0±0.14	34.0±0.13
Multiparous milked thrice per day	7185.6±51.9	288.7±2.89	242.2±2.71	40.3±0.19	33.9±0.20
Probability	0.1184	0.3773	0.2212	0.8779	0.6315

However, they are not in agreement with those of Amos *et al.* (1985), Allen *et al.* (1986) and Hart *et al.* (2013) who reported that increased milking frequency caused a larger increase in milk yield or milk composition in first parity cows than those in older cows.

The present results are also different from those of Poole (1982) and DePeters *et al.* (1985) who reported that older cows respond better to frequent milking than heifers. Also, Bortacki *et al.* (2017) found that increasing milking times affected multiparous cows more effectively than heifers, since in the case of the youngest cows daily gains were about 5.5%, while with the older cows they ranged from 12 to 19.2%.

Likewise, Atashi (2015) reported a significant interaction of milking frequency and parity on the response to increasing milking frequency for milk yield, since the percentages of increase in 305-d milk yield due to increasing milking frequency from twice to thrice daily were 12.34, 14.02, 12.79, and 14.76% for cows in parity 1 to ≥ 4 , respectively. Moreover, Atashi (2015) emphasized that the interactions were most important during early-lactation.

CONCLUSION

From this study, it was concluded that cows milked 3 times per day produced significantly more milk, fat and protein yields and fat percentage than those milked 2 times per day, but protein percentage was not affected. However, responses to increase milking frequency were low. Also, our results showed that there is no interaction between milking frequency and parity. Thus in Moroccan conditions, it appears that the amount of milk increase is not very important to compensate for the increase in labor requirements and the cost of that extra labor.

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