BRIEF COMMUNICATION: Effect of milking frequency and concentrate supplementation on milk production during an extended lactation in grazing dairy cows

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Keywords: extended lactation; concentrate supplementation; milking frequency.

INTRODUCTION

Extending the lactation for longer than 300 days can be used to maintain a high level of milk production, improve reproductive function, and animal welfare. Extended lactations of ~600 days in milk (DIM) in pasture-based systems could benefit the dairy industry by maintaining a relatively constant milk supply throughout the season, improving labour conditions, and reducing on-farm costs (Kolver et al., 2007). Milk production during an extended lactation is dependent upon cow genetic merit, nutrition, and milking frequency (MF) (Sorensen et al., 2008; Kolver et al., 2007). Grazing dairy cattle milked during an extended lactation of ~420 DIM increased milk production during the second spring when pasture quantity and quality were at a maximum. Concentrate supplementation during the entire extended lactation (Kolver et al., 2007), or during the second winter/spring period (Phyn et al., 2009) resulted in greater milk production from grazing dairy cattle. Improvements in lactation persistency and milk yield were also reported when MF was increased from twice daily (2X) to thrice daily (3X) in cows in extended lactation. These improvements were additional to increases in milk production due to nutritional supplementation (Sorensen et al., 2008). As short-term increases in MF at the beginning of the lactation have been reported to increase milk yield subsequent to the return of cows to 2X, it was hypothesised that short-term increases in MF during the second season of production may result in sustained increases in milk production. Therefore, the objective of this study was to determine the short-term effects of concentrate supplementation and increases in MF on milk production in grazing dairy cows during an extended lactation.

MATERIAL AND METHODS

All animal procedures were approved by the Ruakura Animal Ethics Committee (Hamilton, New Zealand). One hundred and twenty non-pregnant Holstein-Friesian cows (DIM ~268, milked 2X, milk yield averaged 12.5 kg/day) from the Westpac Taranaki Agricultural Research Station, Hawera were assembled in May 2010 to be milked in an extended lactation. Based on milk production (~328 DIM) and live weight (LW), the cows were randomly allocated to one of four treatments (n = 30/treatment) in a completely randomised design with a 2 x 2 factorial arrangement for 68 days, to test the effects of MF and concentrate supplementation. Treatments were: (1) Milked 2X and no-concentrate supplementation (2XNS); (2) Milked 2X and 6 kg DM/cow/day of concentrate supplementation (2XS); (3) Milked 3X and no-concentrate supplementation (3XNS); (4) Milked 3X and 6 kg DM/cow/day of concentrate supplementation (3XS). All cows were milked in the morning (05:30 h) and afternoon (14:30 h) and those assigned to 3X were additionally milked at 22:00 h. Animals offered concentrate were gradually acclimated for 14 days (~313 to 327 DIM). Afterwards concentrate was offered to cows during the 05:30 h (3 kg DM) and 14:30 h (3 kg DM) milking. Concentrate ingredients were pelleted and included maize (48%), barley (41%), wheat middlings (4.1%), molasses (4.6%), and minerals. Cows were offered a generous pasture allowance of 40 kg DM/cow/day to ground level, plus pasture silage. Post grazing residuals were used to determine pasture allocation (residuals ≥1600 kg DM/ha). During the carryover period, cows were offered a generous allowance of pasture only and milked 2X until dry-off.

Individual cow milk yields were recorded daily and milk composition was determined weekly. Live weight and body condition score (BCS) (1-10 scale where 1 = Emaciated and 10 = Obese; Roche *et al*., 2004) were collected weekly for the first five months of the experiment and fortnightly for the rest of the lactation. Milk production records from ~328 to 396 DIM and ~397 to 475 DIM were used to analyse the treatment and carryover periods respectively. Cows were removed from the experiment if milk yield averaged below 4.0 kg/d for two consecutive weeks. Sixteen cows (four per treatment) were dried-off due to low production during the carryover period and were removed from analysis in the carryover period. Live weight, BCS, and milk production data from ~299 to 313 DIM were used for covariate analysis. The statistical analysis included the random effect of cow, fixed effects of MF and supplement and the interaction between MF and supplementation. Data were analysed using a mixed model fitted using REML in GenStat (Payne *et al*., 2009).

RESULTS AND DISCUSSION

There were no interactions between MF and concentrate supplementation for any production traits in the treatment or carryover periods. Milk production was affected by increased MF and concentrate supplementation during the treatment period but there was no carryover effect (Table 1). Cows milked 3X produced 1.1 kg of milk/day more than cows milked 2X. This response is 0.5 kg/day less than that reported by Phyn *et al.* (2011) in grazing cows milked 3X immediately after parturition. In agreement with Phyn *et al.* (2011), however, there was no significant carryover effect when the cows were changed from 3X to 2X milking for the rest of the lactation. In the current study, 3X milking reduced milk protein and fat percentages, although, increasing MF in early lactation had little effect on milk composition (Norgaard *et al.,* 2005; Wall & McFadden, 2007). Cows temporarily milked more frequently in early lactation increased milk production (Dahl *et al.,* 2004; Wall & McFadden, 2007); but, these results were obtained in North American Holstein-Friesian cows with high milk yield and offered total mixed ration diets. Increases in milk production associated with increased MF are regulated by local changes in the mammary gland that are thought to lead to increased mammary epithelial cell numbers via enhanced cell proliferation, and activity (Capuco *et al.,* 2003; Hanigan *et al.,* 2008). However, there are no consistent effects of increased MF on mammary enzyme activity or in the expression of genes involved in milk protein and fat synthesis (Grala *et al.,* 2011; Norgaard *et al.,* 2005). In the present study, the increase in milk yield recorded in cows milked 3X may have been associated with increasing mammary cell activity. If this occurred the effect was temporary and did not continue after cows were returned to 2X milking.

Supplementation with concentrate during the second winter/spring of extended lactation increased the yields of milk by 1.3 kg/day and protein by 0.06 kg/day, and tended (P <0.09) to increase milk fat yield by 0.03 kg/day. Milk fat content decreased while protein content was not affected by concentrate supplementation. Kolver *et al.* (2007) and Phyn *et al.* (2009) also reported greater milk and milk component yields in cows supplemented with concentrate during an extended lactation.

TABLE 1: Production parameters of four groups of 30 lactating cows assigned to be milked two (2X) or three (3X) times daily and fed a pasture allowance of 40 kg dry matter/cow/day alone (NS) or with a 6 kg DM/cow/day of concentrate supplementation (S) for 68 days during an extended lactation. Mean values and standard error of the difference (SED) are presented. Bolding of P values indicates significance (P <0.05). MF = Milking frequency; SUP = Supplement.

Variable	Treatment				SED	P value		
	2XNS	3XNS	2XS	3XS		MF	SUP	MFxSUP
Treatment period[1]								
Milk yield (kg/day)	12.0	12.9	13.1	14.4	0.4	**0.002**	**<0.001**	0.57
Milk protein yield (kg/d)	0.51	0.52	0.57	0.58	0.02	0.49	**<0.001**	0.76
Milk fat yield (kg/d)	0.60	0.60	0.63	0.63	0.02	0.97	0.09	0.76
Milk protein (%)	4.27	4.07	4.33	4.07	0.04	**<0.001**	0.39	0.37
Milk fat (%)	5.01	4.79	4.87	4.50	0.11	**<0.001**	**0.004**	0.33
Live weight (kg)	531	529	543	549	3	0.31	**<0.001**	0.07
Body condition score[3]	4.9	4.8	5.1	5.1	0.1	0.19	**<0.001**	0.99
Carry over period[2]								
Milk yield (kg/day)	11.4	11.4	11.1	11.9	0.7	0.45	0.94	0.51
Milk protein yield (kg/d)	0.50	0.48	0.47	0.50	0.03	0.67	0.64	0.43
Milk fat yield (kg/d)	0.57	0.55	0.55	0.57	0.04	0.95	0.92	0.41
Milk protein (%)	4.39	4.36	4.28	4.28	0.07	0.81	**0.04**	0.81
Milk fat (%)	4.97	4.89	5.01	4.97	0.13	0.54	0.52	0.84
Live weight (kg)	578	574	582	590	6	0.69	**0.02**	0.16
Body condition score[3]	5.6	5.4	5.9	5.7	0.1	0.17	**0.02**	0.90

[1]Treatment period: Production data from ~328 to 396 days in milk.
[2] Carry over period: Production data from ~397 to 475 days in milk.
[3]Body condition score: 1 = Emaciated to 10 = Obese (Roche et al., 2004).

Norgaard *et al.* (2005) reported that higher energy diets increased milk production by 17 to 24% in early lactation, which was associated with greater mammary enzyme activity and cell proliferation. Therefore, in the present study, greater milk production observed in supplemented cows could have been a result of greater nutrient flow, hormonal signal, and/or mammary cell activity.

Supplementation with concentrate did not affect milk production in the carryover period. In comparison, Phyn *et al.* (2009) also reported that concentrate supplementation during the second winter did not affect milk production in the carryover period; however, there was a numerical response to concentrate supplementation that increased milk, fat, and protein yield by 10%. Butler *et al.* (2010) reported that, compared with 3 kg/day of concentrate supplementation, 6 kg/day during the second winter increased milk production in the carryover period in cows during an extended lactation. In this study, cows were housed indoors and received a 50% grass silage:50% maize silage (DM basis) diet *ad libitum* during the winter treatment whereas in the present study cows grazed large allowance of pasture. In the current study the carryover period was 78 days, compared with ~330 days and ~301 days in the studies of Butler *et al.* (2010) and Phyn *et al.* (2009) respectively. This could explain the differences among the studies.

Cows supplemented with concentrate were heavier and had a higher BCS than non-supplemented cows (Table 1). It is likely that supplemented animals had a greater dietary energy intake that was directed towards body energy reserves. This result is consistent with previous studies where concentrate supplementation increased LW and BCS during extended lactation (Phyn *et al.,* 2009). In contrast, LW and BCS were not affected by 68 days of increased MF during extended lactation (Table 1).

In conclusion, dairy cattle milked 3X from 328 to 396 DIM increased milk yields relative to 2X, but this response did not carry over to the rest of lactation. Furthermore, milk fat and protein yields were not increased by 3X milking. Supplementing with concentrate temporarily increased milk and milk component yields; however, the extra nutrients were also used to increase LW and BCS.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of Carol Leyton-Davis and Kirsty McLeod, the Westpac Taranaki Agricultural Research Station technical team (Tessa Reedy, Brenna Dobson, and Emma Cook), farm manager (Brett Thomson) and farm staff. Dr. Steve Davis' contributions to experimental design are also gratefully acknowledged. This research was funded by New Zealand dairy farmers through DairyNZ Inc. and the Foundation of Research, Science and Technology (contract DRCX0801).

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