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Once-daily milking during late lactation in pasture-fed dairy cows has minor effects on feed intake, body condition score gain, and hepatic gene expression

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ABSTRACT

Milking cows once daily (1×) is a management practice occasionally used during mid/late lactation in pasture-based systems. It has been postulated that 1× milking will reduce dry matter intake (DMI) and increase body condition score (BCS) gain; however, this has not been quantified. Lactating, pregnant Holstein-Friesian dairy cows (n = 52) were allocated to either 1× or twice-daily (2×) milking in mid-January (summer, 175 d in milk). To obtain accurate DMI measurements, cows underwent 4 periods in a Calan gate indoor feeding facility, interspersed with grazing outdoors. Milk production, body weight (BW), and BCS were recorded 2 wk before treatment start (−2 wk) and weekly thereafter. Blood variables were recorded at −2 wk and weekly when indoors. Liver was biopsied at −2, 2, and 10 wk, and hepatic gene expression measured using quantitative PCR. Milking cows 1× tended to lower DMI (17.8 vs. 18.2 kg of dry matter), but increased BCS gain (0.36 vs. 0.13 BCS units) and BW (546 vs. 533 kg) at wk 12 relative to 2×. The greater BCS and BW of cows milked 1× compared with 2× were reflected in lower plasma concentrations of nonesterified fatty acids and lower transcription of genes involved in the oxidation of fatty acids, indicating reduced release and processing of fatty acids. Cows milked 1× produced 20% less milk, and although milk fat and protein concentrations were increased relative to cows milked 2×, yields of fat and protein were 14 and 17% less, respectively. The reduction in milk production with 1× milking (14.1 vs. 16.8 kg/cow per d energy-corrected milk) was accompanied by increases in blood concentrations of glucose and insulin, with a concurrent decrease in the transcription of the insulin receptor and gluconeogenic genes. These results indicate a coordinated response to reduce glucose production due to decreased mammary demand. Expression of 2 genes linked to inflammation and adipokine signaling was reduced in cows milked 1× and may indicate a lower inflammatory state in the liver of cows milked 1× in late lactation. No effect was found of milking frequency during late lactation on milk production in the subsequent lactation. In summary, although 1× milking tended to reduce DMI and increase BCS in late lactation, these effects were lower than what is commonly supposed in pasture-based dairy systems. The modest BCS gains need to be considered with the reduced milk production when adopting 1× milking as a management strategy.

Key words: milking frequency, dry matter intake, once-daily milking, body condition score

INTRODUCTION

In pasture-based dairy systems, cows are usually milked twice daily (2×). However, milking cows once daily (1×) in late lactation is a strategy occasionally used by farmers to reduce the amount and cost of labor associated with milking (Clark et al., 2006; Bewsell et al., 2008; Stelwagen et al., 2013), to reduce feed demand, to increase BCS, or a combination of these. In particular, because the success of a pasture-based dairy system is reliant on low input costs, 1× milking in late lactation has become increasingly popular in these production systems because it is a low-cost strategy to help achieve calving BCS targets that optimize milk production and reproduction during the subsequent lactation (O'Driscoll et al., 2010; Douglas et al., 2011).

The effect of 1× milking in late lactation on BW or BCS, DMI, and nutrient partitioning is, however, not well characterized, despite research consistently indicating a decrease in milk production relative to 2× milking (Lynch et al., 1991; O'Brien et al., 2002; Ferris et al., 2008). This lower milk production in cows milked 1× should improve energy status and BCS gain if feed intake is not reduced to the same degree. In grazing trials, where individual DMI was not measured, the BW

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of cows milked 1× was 13 to 15 kg greater than the BW of cows milked 2× (Lynch et al., 1991; O'Brien et al., 2002); however, BCS was either not affected (O'Brien et al., 2002) or not measured (Lynch et al., 1991). In an Irish study, Ferris et al. (2008) used a Calan gate feeding system and reported that housed, grass-silage- and concentrate-fed cows milked 1× did not differ from their 2× counterparts in DMI, BW, or BCS. Despite this research, DMI and BCS changes in pasture-fed cows milked 1× during late lactation have not been accurately quantified.

We have previously reported improvements in the metabolic status of grazing cows when milked 1× either immediately postcalving or during a period of feed restriction in early lactation (Kay et al., 2013; Phyn et al., 2014). Plasma concentrations of glucose and insulin were greater, and nonesterified fatty acids (**NEFA**) were reduced, in cows milked 1× compared with those milked 2× (Kay et al., 2013; Phyn et al., 2014), indicating a more positive energy balance. Additionally, hepatic expression of genes involved in gluconeogenesis (glucose-6-phosphatase catalytic subunit, ***G6PC***; phosphoenolpyruvate carboxykinase 1, ***PCK1***), fatty acid β-oxidation (carnitine palmitoyltransferase 1A, ***CPT1A***; carnitine palmitoyltransferase 2, ***CPT2***), and ketogenesis (3-hydroxy-3-methylglutaryl-CoA synthase 2, ***HMGCS2***), were lower in cows milked 1×, supporting the positive metabolic effects reported (Grala et al., 2014a). However, to our knowledge, no published studies are available investigating the underlying metabolic and physiological response to 1× milking during late lactation, which may not be as great due to the smaller decrease in milk production at this stage of lactation.

We have also previously reported that short periods of 1× milking during early lactation had short-term positive carry-over effects on metabolic status once cows were switched to 2× milking as plasma glucose and insulin concentrations remained greater and NEFA concentrations remained lower (Phyn et al., 2014). However, only one published study has measured carry-over effects of 1× milking in late lactation (Ferris et al., 2008). In this experiment, 1× milking in late lactation did not affect milk production in the subsequent lactation when cows were milked 2×. Therefore, although it is unlikely that 1× milking in late lactation will have positive effects on blood hormone and metabolite indicators of metabolic status in the subsequent lactation, this hypothesis has not been examined in pasture-based systems.

The effects of 1× milking in late lactation on milk production, BCS, and DMI need to be quantified to enable farmers to plan feed budgets, cash flows, and manage cows to reach calving BCS targets (Roche et al., 2009). Furthermore, little is known about the metabolic effects of 1× milking during late lactation or the effects on performance in the subsequent lactation. Therefore, the objectives of our experiment were (1) to measure the DMI, BW, and BCS, milk production parameters, plasma hormones and metabolites, and hepatic gene expression of pasture-fed cows milked 1× relative to 2× for 12 wk in late lactation, and (2) to determine the effects of 1× milking on milk production, and plasma hormone and metabolite concentrations in the subsequent lactation when milked 2×.

MATERIALS AND METHODS

This study was conducted at the DairyNZ Lye Farm, Hamilton, New Zealand (37°46′S, 175°18′E) from January 2013 to September 2013. All procedures had prior approval (RAEC 12800 and RAEC 12952) of the Ruakura Animal Ethics Committee, Hamilton, New Zealand.

Experimental Design and Treatments

In mid-January 2013 (summer), 52 multiparous, pregnant Holstein-Friesian cows (175 ± 18 DIM; mean ± SD) were randomly assigned to either 1× or 2× milking (n = 26 per treatment) until dry-off (mean = 259 DIM). All cows had been previously milked 2× from calving in July–August 2012 and were artificially bred in September–October 2012. Pregnancy was confirmed by ultrasonography in early January 2013 (108 d after the planned start of mating; September 23, 2012). Daily milking times were 0700 h for 1× milking (24 h interval), and 0700 and 1500 h for 2× milking (16/8 h interval). Cows were dried off individually with the timing based on milk production and BCS as outlined by Macdonald and Penno (1998) and Macdonald et al. (2005). The final dry-off date was 56 d (May 10) before the planned start of calving in July 2013. During the nonlactating period, all cows were managed to reach a BCS target of 5.0 at calving (10-point scale, where 1 is emaciated and 10 is obese; Roche et al., 2004). Following calving in July 2013, all cows were milked 2×.

Grazing Management and Supplementary Feeding

The cows grazed perennial ryegrass-white clover pasture from calving in July–August 2012. From the January 14, 2013, cows underwent 4 periods of 18 d in a Calan gate (American Calan, Northwood, NH) indoor feeding facility (Hamilton, New Zealand), interspersed with 3 periods of 10 d grazing outdoors.

Indoors. In the Calan gate facility, cows were individually offered freshly cut pasture and pasture silage (2:1 ratio) ad libitum twice daily, allowing for at least