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Effects of feed restriction and prolactin-release inhibition at drying off on metabolism and mammary gland involution in cows

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ABSTRACT

A cow's risk of acquiring a new intramammary infection during the dry period increases with milk production at drying off and decreases as mammary gland involution progresses. A method commonly used to reduce milk production is a drastic reduction in feed supply in the days that precede drying off. Milk production can also be reduced by inhibiting the lactogenic signal driven by prolactin (PRL). This study aimed to compare the effects of these 2 drying-off procedures on metabolism, immunity, and mammary gland involution in cows. A total of 24 Holstein cows in late lactation were assigned to 1 of 3 treatments based on milk yield, somatic cell count, and parity. The cows were fed a lactation diet until drying off (control; n = 8), only dry hay during the last 5 d before drying off (DH; n = 8), or the same lactation diet as the control cows but with twice-daily i.m. injections of 4 mg of quinagolide, a specific inhibitor of PRL release, from 5 d before drying off until 13 d after (QN; n = 8). Quinagolide induced a decrease in PRL concentration in blood and in milk and mammary secretions on all the injection days. Interestingly, PRL was also depressed in the blood and milk of the hay-fed cows before drying off. Both the QN and DH treatments induced a drop in milk production, which averaged 17.9 and 10.1 kg/d for the QN and DH cows, respectively, at drying off in comparison with 24.8 kg/d for the control cows. Both BSA concentration and Na^+-to-K^+ ratio increased faster in the mammary secretions of both the DH and QN cows than in those of the control cows, whereas citrate-to-lactoferrin ratio, another indicator of involution rate, decreased faster. The DH treatment decreased blood concentrations of glucose and most amino acids and increased blood concentrations of β-hydroxybutyrate and nonesterified fatty acids. Quinagolide increased blood glucose but did not affect the other metabolites. The serum harvested on d −1 from the hay-fed cows reduced peripheral blood mononuclear cell proliferation and IL-4 production, whereas the serum from the quinagolide-treated cows had no effect. In conclusion, this experiment shows that PRL-release inhibition could be a new alternative for reducing milk production before drying off and for hastening mammary gland involution without disturbing the metabolism of the cow.
Key words: quinagolide, dry period, immunity, lymphocyte

INTRODUCTION

The lactation cycle of the dairy cow requires a dry period to renew mammary secretory cells. Although this period is important for optimal milk production in the subsequent lactation, the cow is highly susceptible to new IMI during the first 3 wk of the dry period (Eberhart, 1986). With increasing milk production, drying off has become a challenging period for dairy cows. Although milk is no longer removed, the mammary gland temporarily continues to synthesize milk, which is an excellent medium for bacterial growth, and thus milk accumulation and leakage via the teats can occur, facilitating the entry of microorganisms into the mammary gland (Oliver and Sordillo, 1989). Consequently, the risk of acquiring a new infection during the dry period increases rapidly with the level of milk production (Rajala-Schultz et al., 2005). Once mammary gland involution is completed, within 30 d after cessation of milking, the mammary gland becomes much more resistant to new IMI because of a low fluid volume in the udder and a medium unfavorable for bacterial growth (Breau and Oliver, 1986). As it is now common to dry off cows that are still producing more than 25 kg of milk per day, it is important to develop strategies that reduce milk production before drying off and to hasten mammary gland involution.

A common drying-off practice among farmers involves a drastic short-term reduction in feed supply in the days that precede drying off. Although this method is effective for rapidly reducing milk yield (Bushe and Oliver, 1987), such a reduction in nutrient supply at drying off may lead to metabolic problems, especially

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among high-yielding cows. In previous studies, cows fed straw (Odensten et al., 2005) or hay (Bernier-Dodier et al., 2011) at drying off responded with an increase in plasma NEFA concentration comparable to the increase that can be observed in early lactation (Loiselle et al., 2009). In early lactation, metabolic stress is proportional to the negative nutrient balance, and the linkage between milk production and health disorders such as mastitis is well documented (Pryce et al., 1998). This high susceptibility is, in part, related to the fact that some immune functions, such as PMNL phagocytosis and oxidative burst activity, as well as blood lymphocyte responsiveness to mitogenic stimulation, are depressed (Kehrli et al., 1989a,b; Moreira da Silva et al., 1998). Recently, Ster et al. (2012) observed that immune functions, such as lymphocyte multiplication and cytokine release, were inhibited by serum obtained from periparturient cows and that this inhibition is directly related to NEFA concentration in the serum. It is therefore possible that part of the gain in disease resistance obtained by reducing milk production at drying off, by means of feed restriction, is loss due to an immunosuppression.

Milk production can also be reduced by decreasing the lactogenic signals driving milk production. Lacasse et al. (2011) recently showed that inhibiting prolactin (**PRL**) secretion with quinagolide gradually decreased milk production in cows at peak lactation. When applied to cows in late lactation, the same approach induced a sharp decrease in milk production within 24 h, and some parameters suggested that involution had been hastened (Ollier et al., 2013). The effect of this strategy on the immune system and metabolism of cows has not yet been assessed. The present study aimed to compare the effects of PRL-release inhibition as a drying-off procedure with those of a drastic reduction in feed supply in the days preceding drying off on metabolism, immunity, and mammary gland involution in cows.

MATERIALS AND METHODS

Animals and Experimental Design

The experiment was conducted in accordance with the guidelines of the Canadian Council on Animal Care (1993). A total of 24 Holstein cows in late lactation (327 ± 16 DIM at drying off) housed at Agriculture and Agri-Food Canada's Dairy and Swine Research and Development Centre (Sherbrooke, QC, Canada) were assigned to 1 of 3 treatments according to their milk yield, SCC, and parity. The cows were fed ad libitum (1) a late-lactation diet (containing dry hay, grass silage, corn silage, corn grain, soybean meal, and nonmineral and mineral supplements; Table 1) until drying off (control; n = 8); (2) only dry hay during the last 5 d before drying off (**DH**; n = 8); or (3) the same late-lactation diet as the control cows but with twice-daily (at 0930 and 2130 h) i.m. injections of 4 mg of quinagolide (Ferring, Wallisellen, Switzerland) from 5 d before drying off until 13 d after (**QN**; n = 8). The control and DH cows received injections of the solvent (water). After drying off, the 24 cows were fed ad libitum a dry period diet containing (on a DM basis) 74.9% dry hay and 25.1% TMR (containing corn silage, soybean meal, and mineral supplement; Table 1). Feed intake was recorded daily throughout the experiment, and each cow's BW was determined at the start and at the end of the experiment.

Table 1. Ingredient composition of diets

Ingredient composition (% of DM)	Late lactation diet	Dry hay diet	Dry period diet
Dry hay	7.3	100.0	74.9
Grass silage	28.8	0.0	0.0
Corn silage	28.6	0.0	11.3
Corn grain	21.3	0.0	0.0
Soybean meal	9.4	0.0	12.2
Nonmineral supplement	2.6	0.0	0.0
Mineral supplement	2.1	0.0	1.6

Milk and Mammary Secretion Collection

The cows were milked twice daily, at 0730 and 2030 h, and milk yield was recorded at each milking during the last 2 wk before drying off. Milk samples (60 mL) were manually collected from each quarter just before the morning milking on the last 7 d before drying off (d −7 to −1) and then mixed together for each cow and each day. After the last milking, each quarter was treated with dry cow therapy containing penicillin and novobiocin (Novodry Plus; Pfizer Canada Inc., Kirkland, QC, Canada). Mammary secretions (60 mL) were manually collected from 1 quarter at 0730 h on d 1, 3, 5, 7, 10, and 14 after the last milking. The sampled quarter was alternated at each sampling and the teat was dipped into a teat protection sealant containing 0.1% triclosan (Uddergold Dry; Ecolab Inc., St. Paul, MN) after the sample was taken. Quarters with high SCC (>250 cells/μL) or detectable pathogens before the start of the experiment were excluded from sampling. The samples were used to measure SCC and were then skimmed by centrifugation (1,900 × *g*, 4°C, 15 min) and stored at −20°C until determination of PRL, BSA, lactoferrin, citrate, Na^+, and K^+ concentrations, as well as gelatinase activity.