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Induced lactation in heifers: Effects of dexamethasone and age at induction on milk yield and composition

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ABSTRACT

Milk production in heifers induced into lactation is lower than that of postpartum primiparous cows. A method to improve milk production in induced lactations may provide opportunities for increased profitability as well as increase our understanding of the mechanisms that regulate mammary gland development and colostrum composition. The present study was conducted to determine if dexamethasone administration at the onset of milking or age at lactation induction would affect milk production in heifers induced into lactation. Holstein heifers at 14 [n = 20; 354 ± 38 kg of body weight (BW)] and 18 mo of age (n = 20; 456 ± 30 kg of BW) were assigned randomly to dexamethasone (DEX) or control (CON) treatment groups in a 2 × 2 factorial arrangement with age and dexamethasone treatment as the 2 factors. Heifers were induced into lactation with daily subcutaneous injections of estradiol-17β and progesterone (0.075 and 0.25 mg/kg of BW per d, respectively) on experimental d 1 to 7. They also received bovine somatotropin (bST) every 14 d beginning on experimental d 1. Milking began on experiment d 18 (lactation d 1). Dexamethasone (10 mg) was administered on lactation d 1 and 2 following the morning milking; CON heifers did not receive dexamethasone. Milk yield from d 2 to 15 of lactation of heifers receiving DEX (7.8 kg/d) was greater than that of CON heifers (6.0 kg/d) but was similar thereafter through 305 d of lactation (18.2 kg/d). Milk production to d 11 was similar for 14- and 18-mo-old heifers but was greater for 18- (18.9 kg/d) than for 14-mo-old animals (17.4 kg/d) through 305 d in milk. Milk fat percentage increased initially and was greater in DEX (4.51%) compared with CON (3.53%) heifers until 21 d in milk. Milk protein and lactose concentrations were not affected by DEX treatment. Age at induction did not affect milk fat, protein, or lactose percentages. Mean milk IgG concentration declined from 107.4 mg/mL on d 1 to 5.0 mg/mL on d 7 of lactation, tended to be greater for 18- compared with 14-mo-old heifers, and was not different due to DEX treatment. Administration of DEX to heifers induced into lactation increased initial milk production during the first 2 wk of lactation but this effect did not persist through 305 DIM. Treatment with DEX appeared to stimulate mammary cell differentiation but did not change the rate of decline of milk IgG concentrations. Higher milk yield in 18-mo-old heifers may be due to greater mammary epithelium, higher body mass, or both.
Key words: induced lactation, dairy heifer, dexamethasone, age

INTRODUCTION

Lactation can be induced successfully in 15-mo-old dairy heifers; however, they produce less milk than postpartum animals (Smith and Schanbacher, 1974; Macrina et al., 2011b). This is not surprising considering they are much younger than postpartum heifers that calve at 24 to 25 mo of age. A benefit to inducing lactation at a young age is that milk could be harvested and sold before heifers are old enough to calve. Current lactation-induction methods are based on the 7-d estrogen-progesterone injection protocol developed by Smith and Schanbacher (1973); however, lower doses of estradiol have been used (Erb et al., 1976; Byatt et al., 1997; Magliaro et al., 2004). Administration of bST to heifers during induced lactation increases milk production by 14.7% compared with control animals that did not receive bST (Macrina et al., 2011b). However, even with bST supplementation, inducing lactation in 15-mo-old heifers is not more profitable than conventional rearing methods, where heifers calve at 25 mo (Macrina et al., 2011b). The potential exists to increase the economic value of induced lactation by improving milk production. In a previous study, Macrina et al. (2011a) reported a 36% increase in milk production by 15-mo-old heifers that received bST concurrent with the estrogen-progesterone treatment to induce lactation.

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Milk production in heifers induced into lactation increases slowly compared with that in postpartum animals (Smith and Schanbacher, 1973; Kensinger et al., 1979; Fowler et al., 1991), and peak yields are not attained until well after 50 DIM (Macrina et al., 2011a,b). Mammary gland development may continue for longer after milking begins in heifers induced into lactation compared with postpartum animals. It has been speculated that heifers treated with bST at the same time estrogen and progesterone are administered to induce lactation have a greater number of mammary epithelial cells (**MEC**) compared with heifers that do not receive bST during this time (Macrina et al., 2011a). In that study, heifers reached peak milk production at 149 DIM, which appears to be slightly sooner than the 175 d to peak yield when heifers were treated with bST after induced lactation was established (Macrina et al., 2011b). It is not known if early administration of bST affected the extent or rate of MEC differentiation. Keys et al. (1989) calculated that 78% of the milk production difference between Holstein and Hereford cows was due to differences in secretory capacity per cell. Almost all of the MEC from Holstein parenchymal tissue were highly or intermediately differentiated, whereas 40% of those from Herefords were poorly differentiated (Akers et al., 2006). A strategy to increase the proportion of highly differentiated cells has the potential to improve milk yields in heifers induced into lactation.

Administration of reserpine or recombinant placental lactogen has also been investigated as a means to stimulate mammary development and improve milk production in cattle induced into lactation. Reserpine caused an increase in plasma prolactin concentrations (Collier et al., 1975, 1977; Peel et al., 1978); however, the results for milk production were variable, with some studies reporting an increase (Collier et al., 1975, 1977) and others showing no effect (Peel et al., 1978; Davis et al., 1983). Total mammary DNA is higher in heifers induced into lactation and treated with recombinant placental lactogen (**rbPL**) compared with controls, recombinant prolactin did not have an effect, and both stimulated mammary differentiation (Byatt et al., 1994). In a subsequent study, the same group reported that rbPL administration resulted in a 20% increase in milk yield through 9 wk of lactation but this was not statistically significant due to high coefficients of variation (Byatt et al., 1997). Although both prolactin and rbPL show promise for increasing milk production in induced lactations, synthetic glucocorticoids such as dexamethasone are more readily available.

Plasma levels of glucocorticoids increase around the time of parturition, and glucocorticoids are required for differentiation of mammary epithelial cells (Heald, 1974; Casey and Plaut, 2007). The synthetic glucocorticoid dexamethasone (**DEX**) has been used in some induced-lactation protocols. Heifers that received DEX produced more milk initially, but by d 21 all induced-lactation treatments resulted in similar milk production (Fulkerson, 1978). The treatments that used DEX were 42 d in length with estrogen and progesterone administered every 3 d. The only induced-lactation treatment that did not include DEX was one that involved the standard administration of estrogen and progesterone for 7 d. Chakriyarat et al. (1978) reported that DEX administered at the onset of milking increased the number of animals that produced >5 kg/d but did not improve overall milk yield in cows (n = 13) and heifers (n = 6) induced into lactation using the 7-d estradiol-progesterone protocol. Increased success rate in cows also was observed by Davis et al. (1983). Overall, very little research has been conducted to evaluate the effects of DEX administration on milk yields of heifers induced into lactation.

Furthermore, limited feed intake capacity at 15 mo may have contributed to the longer time for heifers induced into lactation to reach peak production (Macrina et al., 2011b). Currently, the optimal age at which to induce lactation is not known. It is possible that older heifers could produce more milk than their younger herdmates. Studies to examine the effects of age and DEX administration on milk production could provide useful information on optimizing milk production in heifers induced into lactation. Although induced lactation has not been approved by the US Food and Drug Administration, the need for increased food production over the next 50 yr might make it a viable technology. In addition, data collected on heifers induced into lactation could shed light on the regulation of mammary gland development and colostrum composition. The objectives of the present experiment were to determine if DEX administration at the onset of milking or older age at induction of lactation would increase milk production and affect mammary secretion composition in heifers induced into lactation.

MATERIALS AND METHODS

Estrous cycles were synchronized using 2 injections of prostaglandin $F_{2\alpha}$ 14 d apart so that heifers would be in a similar phase of the cycle upon induction of lactation. Heifers were induced in 5 different groups (October, February, April, June, and September) with 8 animals/group beginning on d 4 ± 1 of the estrous cycle. Holstein heifers at 14 (n = 20; 354 ± 38 kg of BW) and 18 mo of age (n = 20; 456 ± 30 kg of BW) were induced into lactation using daily subcutaneous injections of estradiol-17β (0.075 mg/kg of BW; E-8875, Sigma-Aldrich, St. Louis, MO) and progesterone (0.25