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Performance of early-lactation dairy cows as affected by dietary starch and monensin supplementation

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ABSTRACT

The objective of this study was to evaluate the effect of postpartum dietary starch content and monensin supplementation throughout the periparturient period and into early lactation on production performance of dairy cows during early lactation. Prior to parturition, primiparous (n = 21) and multiparous (n = 49) Holstein cows were fed a common controlled-energy close-up diet with a daily topdress of either 0 or 400 mg/d monensin. From d 1 to 21 postpartum, cows were fed a high-starch (HS; 26.2% starch, 34.3% NDF, 22.7% ADF, 15.5% CP) or low-starch (LS; 21.5% starch, 36.9% NDF, 25.2% ADF, 15.4% CP) total mixed ration with a daily topdress of either 0 mg/d of monensin or 450 mg/d monensin (MON), continuing with prepartum topdress treatment assignment. From d 22 through 63 postpartum, cows were fed HS and continued with their assigned daily topdress. Interactions of starch content and MON supplementation were not significant for any of the variables measured. Cows fed HS from wk 1 to 3 postpartum had higher early-lactation milk yields (starch × week interaction) compared with LS cows, but HS cows also had lower percentages of milk fat, true protein, lactose, and total solids during the same period, resulting in similar yields of energy-corrected milk (ECM) between starch treatments. Cows fed HS had higher early-lactation dry matter intake (DMI; starch × week interaction) and lost less body condition score during wk 1 to 3, contributing to improved energy balance postpartum. No effect of starch treatment was observed on apparent total-tract dry matter or starch digestibilities assessed during d 18 to 19 (±2) postpartum, although cows fed the LS diet had greater apparent total-tract NDF digestibility compared with cows fed the HS diet. Cows fed MON had higher DMI and higher milk yields during the first 9 wk of lactation. However, all cows had similar yields of ECM because of trends for lower milk fat content during early lactation. In part because of similar yields of ECM between these treatments and higher DMI for cows fed MON, ECM per DMI during the first 9 wk of lactation was not affected by MON treatment. There was no effect of MON treatment on apparent total-tract dry matter, NDF, or starch digestibilities. Overall, cows fed more propiogenic diets in early lactation (HS or MON) had increased milk yield and DMI during the immediate postpartum period, indicating that diets with greater propiogenic capacity do not have detrimental effects on early-lactation DMI.

Key words: early lactation, starch, monensin

INTRODUCTION

In the period immediately following calving, DMI is insufficient to support the high milk production of early lactation, resulting in a state of negative energy balance (**EB**) that usually begins a few days before calving and reaches the greatest deficit about 2 wk after parturition (Butler, 2000). This state of negative EB results in the increased mobilization of adipose tissue, manifested as the release of NEFA into circulation to be metabolized by the liver and other tissues and incorporated into milk fat in the mammary gland. Higher DMI postpartum generally results in lower circulating NEFA and has been associated with improved health, performance, and less severe postpartum negative EB (Ingvartsen and Andersen, 2000).

Optimizing DMI during the periparturient period is especially important to provide sufficient available energy to support milk production. Because of the increased glucose demand for milk lactose synthesis, hepatic glucose production nearly doubles within 11 d of calving compared with prepartum hepatic glucose output (Reynolds et al., 2003). Propionate that is produced via fermentation of starch in the rumen is the main precursor for hepatic glucose production (Aschenbach et al., 2010). Monensin is an ionophore that has also been shown to increase ruminal propionate production (Armentano and Young, 1983), likely from changes in the populations of gram-positive bacteria along with changes in the metabolism of gram-negative bacterial

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populations in the rumen that occur with ionophore treatment (McGuffey et al., 2001).

Allen et al. (2009) proposed that hepatic energy status is a major regulator of DMI in dairy cows. When hepatic oxidative fuel supply (propionate and NEFA) exceeds hepatic energy requirements, the brain is signaled via the vagal afferent nerve to reduce DMI (Allen et al., 2009). This hepatic oxidation theory would suggest that feeding diets that promote greater ruminal propionate production (e.g., high in fermentable starch, monensin supplementation) during early lactation could be hypophagic and thus further reduce DMI during this period of negative EB. If the hepatic oxidation theory applies to the early lactation period, then reducing dietary starch content or fermentability may increase DMI by reducing propionate production in the rumen (Allen et al., 2009). Recent work conducted using early-lactation animals has shown propionate infusion to be more hypophagic in animals with higher liver acetyl CoA concentrations (Stocks and Allen, 2012, 2013), which would occur with higher NEFA mobilization. Because liver energy requirements increase dramatically at the onset of lactation (Reynolds et al., 2003), concurrent with increased adipose mobilization (Ingvartsen and Andersen, 2000), we speculated that NEFA are most likely the predominant hepatic oxidative substrate during this period. Thus, the hypophagic effect of propionate is likely to be reduced in the immediate postpartum period because of these large increases in hepatic energy demands at the onset of lactation (Reynolds et al., 2003).

The efficacy of monensin to decrease periparturient negative EB-associated health disorders, improve energy metabolism, and enhance lactation performance has been demonstrated (Duffield et al., 2008a, b, c). However, based upon the concepts presented in the hepatic oxidation theory, it is of interest to determine whether effects of monensin on performance of postpartum cows are independent of dietary starch content, as both likely will increase supply of propionate. The objectives of the current study were to evaluate the effects of dietary starch content during the immediate postpartum period on intake and production, and to evaluate the effects of peripartal monensin supplementation in conjunction with these diets of differing starch content on DMI, production, feed efficiency, and EB. We hypothesized that increasing starch content during the immediate postpartum period and feeding monensin throughout the periparturient period and into early lactation would enhance milk production and improve energy metabolism without detrimental effects on DMI, and that the effects of monensin on performance would be independent of postpartum dietary starch content.

MATERIALS AND METHODS

Animals and Treatments

All animal procedures were approved by the Cornell University Institutional Animal Care and Use Committee and the experiment was conducted from March to October 2012. The study was a completely randomized design with randomization restricted to balance for expected calving date of primiparous and multiparous cows and previous lactation 305-d mature-equivalent milk production for multiparous cows. A 2 × 2 factorial arrangement of postpartum treatments was used with an early lactation period feeding strategy [high-starch (**HS**) vs. low-starch (**LS**) diet during the first 21 d postpartum] and postpartum monensin supplementation [0 (**CON**) or 450 mg/d (**MON**); Rumensin, Elanco Animal Health, Greenfield, IN] as the variables of interest. In addition, cows that received MON during the postpartum period were fed MON (400 mg/d) beginning on 1 d between d 21 to 28 before expected parturition (average treatment of 25 d; minimum of 14 d on treatment before actual parturition was required for inclusion in the data set). It is our experience that farms that feed monensin typically feed monensin throughout the entire transition period and into established lactation, which is why we chose to continue either monensin or control treatments throughout the entire trial period; in addition, monensin treatment was initiated during the prepartum period to allow time for ruminal adaptation before calving. The HS and LS dietary treatments reflect common feeding strategies on commercial farms and were designed specifically to evaluate whether starch content of the diet fed during the early postpartum period affected DMI and cow performance.

A total of 80 cows were enrolled in the study and the final data set included a total of 70 cows (HS + CON primiparous n = 5, multiparous n = 13; HS + MON primiparous n = 5, multiparous n = 13; LS + CON primiparous n = 6, multiparous n = 13; LS + MON primiparous n = 5, multiparous n = 10). A total of 10 cows were removed from the experiment for reasons not related to experimental treatments (6 calved before having a minimum of 2 wk on the dry period treatment, 3 calved with twins, 1 was removed from data set for being an outlier with milk production that was 3 SD below the mean). Lactating cows were dried off at least 45 d (average 53-d dry period length) before expected parturition, and moved to the experimental tiestall barn approximately 28 d before expected parturition where they began consuming the experimental close-up dry cow diet (Table 1).