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Prepartum nutritional strategy affects reproductive performance in dairy cows

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ABSTRACT

Negative energy balance during early postpartum is associated with reduced reproductive performance in dairy cows. A pooled statistical analysis of 7 studies completed in our group from 1993 to 2010 was conducted to investigate the association between prepartum energy feeding regimen and reproductive performance. The interval from calving to pregnancy (days to pregnancy, DTP) was the dependent variable to assess reproductive performance. Individual data for 408 cows (354 multiparous and 54 primiparous) were included in the analysis. The net energy for lactation (NE_L) intake was determined from each cow's average dry matter intake and calculated dietary NE_L density. Treatments applied prepartum were classified as either controlled-energy (CE; limited NE_L intake to ≤100% of requirement) or high-energy (HE; cows were allowed to consume >100%) diets fed during the far-off (FO) or close-up (CU) dry periods. Cow was the experimental unit. The Cox proportional hazard model revealed that days to pregnancy was shorter for CE (median = 157 d) than HE (median = 167 d) diets during the CU period [hazard ratio (HR) = 0.70]. Cows fed HE diets during the last 4 wk prepartum lost more body condition score in the first 6 wk postpartum than those fed CE diets (−0.43 and −0.30, respectively). Cows fed CE diets during the FO period had lower nonesterified fatty acids concentrations in wk 1, 2, and 3 of lactation than cows fed HE diets. Higher nonesterified fatty acids concentration in wk 1 postpartum was associated with a greater probability of disease (n = 251; odds ratio = 1.18). Cows on the CE regimen during the FO period had greater plasma glucose concentrations during wk 1 and 3 after calving than cows fed the HE regimen. Higher plasma glucose (HG) concentration compared with lower glucose (LG) in wk 3 (HG: n = 154; LG: n = 206) and wk 4 (HG: n = 71; LG: n = 254) after calving was associated with shorter days to pregnancy (wk 3: median = 151 and 171 d for HG and LG, respectively, and HR = 1.3; wk 4: median = 148 and 167 d, respectively, and HR = 1.4). In the first 2 wk after calving, cows that received HE diets in the FO period had higher concentrations of total lipids and triglyceride and greater ratio of triglyceride to glycogen in liver than cows fed CE diets. In conclusion, cows fed CE diets during the CU period had a shorter interval between parturition and conception, which may be explained by increased NE_L intake during the first 4 wk postpartum and lower incidence of peripartal diseases. Lower body condition score loss during the first 6 wk postpartum and slightly higher glucose concentration at wk 3 likely contributed to improved reproductive performance.

Key words: transition diet, energy intake, days to pregnancy, controlled energy

INTRODUCTION

Reproductive performance is a major reason for premature culling of dairy cows, having a great effect on lifetime milk production of individual cows (Beever, 2006). Reproductive inefficiency also reduces the number of calves born, which decreases the number of replacements available (Gröhn and Rajala-Schultz, 2000) and further increases the economic losses caused by infertility. Reproductive efficiency in dairy cattle is commonly well below economic targets not only in the United States but also in Ireland, United Kingdom, and Australia (Lucy, 2001).

An index used to measure infertility in dairy herds is days to pregnancy (**DTP**), defined as the time in days from calving to the last breeding in which the cow became pregnant. Because conception does not necessarily occur at the first breeding, cows may have to be inseminated more than once. Feed intake and feeding behavior during the transition period may be related to increased risk for uterine diseases in dairy cattle (Urton et al., 2005; Hammon et al., 2006; Huzzey et al., 2007). Hammon et al. (2006) observed that cows developing uterine disease postpartum experienced decreased DMI beginning 1 wk before parturition. In

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concordance, cows diagnosed with severe metritis after calving were already consuming less DM 2 wk before calving (Huzzey et al., 2007). Excessive plasma concentrations of NEFA and BHBA, which are higher in cows experiencing stronger negative energy balance (**NEB**), are negatively associated with the developmental capacity of oocytes (Leroy et al., 2005) and pregnancy rates (Walsh et al., 2007). Cows with low BCS at 65 d postpartum are more likely to be anovular (Santos et al., 2008), which can compromise pregnancy success at first postpartum insemination.

Negative energy balance is associated with infertility in dairy cows (Jorritsma et al., 2003). Cows are typically unable to achieve the necessary DMI to maintain energy balance in early lactation (Bauman, 2000). Negative energy balance results from a mismatch between the rapid increase in energy requirements at the onset of lactation and the rate of increase in DMI (Butler, 2000). Negative energy balance suppresses pulsatile LH secretion and reduces ovarian responsiveness to LH stimulation, both of which result in reduced fertility (Butler, 2000). Negative energy balance may begin just before calving, reaches its nadir about 2 wk after calving, and on average lasts until approximately 6 wk postpartum (Butler and Smith, 1989; Bell, 1995; Grummer, 2008). The key determinant of the severity of NEB is DMI in early lactation (Lucy, 2001; NRC, 2001). Feeding strategies in the dry period have as a primary objective to maximize DMI in early lactation.

Based on previous reports (Kunz et al., 1985) and on field observations, our group has been motivated to better understand the possible effects of controlled energy feeding during the transition period. The strategy developed was to formulate and feed diets with relatively low energy density (1.30 to 1.38 Mcal of NE_L/kg of DM) during the entire dry period. The incorporation of low-energy ingredients (straw or low-quality grass hays) allows cows to consume feed for ad libitum intake without exceeding their daily energy requirements (Janovick and Drackley, 2010). Benefits of feeding controlled-energy (**CE**) diets prepartum to dairy cows have been reported (Beever, 2006; Dann et al., 2006; Douglas et al., 2006; Janovick and Drackley, 2010). Recently, Janovick et al. (2011) suggested that cows fed CE diets during the dry period had fewer diseases and disorders than cows fed high-energy (**HE**) diets (>100% of NE_L requirement). Feeding HE diets demonstrated that cows can overconsume energy relative to their energy requirement, independent of diet adjustments (Dann et al., 2006; Janovick and Drackley, 2010).

Also, Beever (2006) and Colman et al. (2011) stated that farmers have repeatedly observed easier calving and greater DMI around parturition when energy intake is controlled prepartum. Excess energy consumption prepartum also seems to result in a larger decrease in DMI prepartum compared with cows having CE diets prepartum (Janovick et al., 2011). Such steep changes in DMI prepartum have been associated with increased deposition of lipid in liver postpartum (Drackley et al., 2005). Restricted DMI prepartum was associated with a greater rate of increase and higher DMI postpartum (Douglas et al., 2006; Janovick and Drackley, 2010). Nevertheless, the effect of energy intake prepartum on reproductive performance in dairy cows is still to be assessed. Previous experiments did not have the statistical power necessary to explore such relationships.

The objectives of this study were to examine the associations between feeding CE or HE diets during the dry period and the interval to pregnancy in dairy cows. The effects of prepartum dietary energy regimen on BCS, NE_L intake (**NE_{LI}**), concentrations of glucose, insulin, and NEFA in blood, and concentrations of total lipids, triglyceride (**TG**), and glycogen also were determined. Our hypothesis was that cows fed the CE regimen would have more favorable metabolic health in the transition period and, consequently, shorter DTP. Data from several similar experiments were pooled to investigate these associations.

MATERIALS AND METHODS

Database Construction and Data Collection

The database was developed from 7 experiments completed at the University of Illinois (Urbana) from 1993 to 2010 (Table 1). Individual cow experimental data were obtained from Microsoft Excel (Microsoft Corp., Redmond, WA) files from each experiment. Individual cow data for management, health, and reproduction were obtained from PCDART herd management software (Dairy Records Management Services, Raleigh, NC) or individual cow record cards. A total of 408 cows (354 multiparous and 54 primiparous) were included in the analyses.

Prepartum treatments were defined as follows: (1) HE, where cows were allowed ad libitum access to moderate-energy diets that would allow cows to exceed NRC requirements (NRC, 2001) for NE_L, and (2) CE, where cows either were fed restricted amounts of moderate-energy diets to target NE_L intakes of 80% of NRC requirements or were allowed ad libitum access to high-fiber, low-energy diets to limit NE_L intake to approximately 100% of NRC requirements.

Parity was dichotomized as cows starting first or second lactation in one group (**LAG1**) and cows in the third-or-greater lactation in a second group (**LAG2**). In addition, calving season (winter: December to