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Effect of prepartal and postpartal dietary fat level on performance and plasma concentration of metabolites in transition dairy cows

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ABSTRACT

The objective of this study was to determine the effects of 2 levels of dietary fat (low and high) offered during the prepartal and postpartal periods on dry matter intake (DMI), plasma concentration of metabolites, and milk yield and composition. Twenty-four Holstein dry cows were assigned on d 21 relative to expected parturition date to 1 of 4 treatments in a 2 × 2 factorial arrangement of 2 levels of fat fed during the prepartal period and 2 levels of fat fed during the postpartal period: prepartal low fat and postpartal low fat (LF-LF), prepartal low fat and postpartal high fat (LF-HF), prepartal high fat and postpartal low fat (HF-LF), or prepartal high fat and postpartal high fat (HF-HF). Prepartal and postpartal LF diets contained no fat supplement. Prepartal HF diets contained 1.60% calcium salts of soybean oil. The proportion of calcium salts of soybean oil was increased to 1.70% of DM for the first 21 d of lactation and to 2.27% of DM from d 21 to 56 of lactation in the HF diet. Diets were fed for ad libitum intake from d 21 before calving until d 56 of gestation. Prepartal DMI was lower for cows fed the HF diet compared with those fed the LF diet (12.6 vs. 16.2 kg/d). Postpartum, cows fed the HF-HF and HF-LF diets had, respectively, the lowest and highest DMI, although no significant differences existed between HF-LF and LF-LF. Net energy intake was higher for cows fed the postpartal HF diets compared with those fed the LF diets. Prepartal fat level had no effect on net energy intake. Cows offered the prepartal HF diet had higher milk yield when offered the postpartal LF diet compared with those offered the postpartal HF diet and no effect of the postpartal fat level was detected when cows were fed the prepartal LF diet. Milk composition was similar among treatments. Plasma cholesterol concentration postpartum was higher for cows fed the prepartal LF diet than for those fed the prepartal HF diet (5.16 vs. 3.74 mmol/L) and postpartal fat level had no effect. Prepartal diet had no significant effect on postpartal plasma triglyceride concentration but the postpartal HF diet increased triglyceride and low-density lipoprotein concentrations compared with the postpartal LF diet. In conclusion, switching from a high to a low fat proportion in the postpartal diet may alleviate the negative effects of a high proportion of fat in the prepartal diet as shown by increased feed intake and milk production during the first 56 d of lactation.
Key words: dairy cow, fat, milk yield, transition period

INTRODUCTION

Several studies have been conducted on the effects of dietary fat supplementation on performance, DMI, and milk yield of dairy cows (Onetti et al., 2001; Juchem et al., 2008; Duske et al., 2009) but only a few studies have been undertaken to examine the effects of fat supplementation in transition dairy cows (Grum et al., 1996; Douglas et al., 2004). The transition period begins 3 wk before calving and lasts until 3 wk after calving (Bell et al., 1995) and is associated with an increased risk of metabolic- and production-related diseases (Friggens et al., 2004). This period is marked by a decrease in DMI (Grummer, 1995) and negative energy balance (Rabelo et al., 2003) due to the increasing demand of nutrients for milk production (Bell et al., 1995). As a result, body reserves are mobilized in an attempt to overcome the energy deficit as indicated by increased blood NEFA concentrations (Douglas et al., 2004), which, in turn, may reduce milk yield potential and persistency (Rabelo et al., 2003). According to the NRC (2001), maximizing energy intake during the close-up or prefresh period may rectify this situation in the postpartal period. Fat supplementation during the transition period is one strategy to enhance energy consumption, which then may assist in managing extensive physiological changes in dairy cows.

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One theoretical basis for feeding fat to cows prepartum is to prime the cow to adapt to body fat in the following early lactation (Andersen et al., 2008), which may increase the β-oxidation capacity of long-chain FA in the liver and decrease liver triacylglycerol concentration in the following early lactation (Grum et al., 1996). Because major changes occur before calving in the transition period, implementation of nutritional strategies at this time may have beneficial effects on performance. For example, supplementing dry cows with a saturated source of FA in a feed-restricted diet has been shown to be a positive strategy for priming dairy cows to mobilize body fat in the following early lactation. Moreover, dry cows fed for ad libitum intake a diet with 3.3% flaxseed had higher concentrations of glycogen and lower concentrations of triglyceride (**TG**) in the liver after calving, which may prevent the development of fatty liver (Petit et al., 2007). Therefore, the main objective of the current study was to determine the effects of fat supplementation during the prepartal and postpartal periods and their interactions on feed intake, animal performance, and milk production of dairy cows. Two levels of fat were offered for 21 d of the dry period in an attempt to quantify the effects of dietary fat level on the subsequent lactation performance. The hypothesis was that different fat levels fed during the prepartal and postpartal periods have a differential influence on the productivity of dairy cows.

MATERIALS AND METHODS

Cows, Experimental Design, and Treatments

The experiment was conducted at the Dairy Research Facilities of the Lavark Research Station of Isfahan University of Technology (Isfahan, Iran) using a total of 24 cows. Guidelines for the care and use of animals were approved by the Animal Care Committee of the university. The experiment was carried out from 21 d relative to parturition up to d 56 of lactation. Cows were blocked for similar expected calving dates. All cows in the study calved within 1 wk. Cows within groups were assigned randomly to 1 of 4 treatments (Table 1) in a 2 × 2 factorial arrangement of 2 levels of fat fed during the prepartal period and 2 levels of fat fed during the postpartal period: prepartal low fat and postpartal low fat (**LF-LF**), prepartal low fat and postpartal high fat (**LF-HF**), prepartal high fat and postpartal low fat (**HF-LF**), and prepartal high fat and postpartal high fat (**HF-HF**). At the beginning of the experiment, cows had similar parity (parity 4) and they averaged (mean ± SD) 743 ± 65 kg of BW and 3.5 ± 0.05 of BCS on a scale of 1 to 5 (3.45 for cows fed LF and 3.50 for cows fed HF; Edmonson et al., 1989). Prepartal and postpartal LF diets contained no fat supplement. The prepartal HF diet contained 1.60% calcium salts of soybean oil (**CaSO**). The proportion of CaSO was increased to 1.70% of DM for the first 21 d of lactation and to 2.27% of DM from d 21 to 56 of lactation in diet HF.

Cows were housed in tie-stalls and allowed to exercise for 1 h every afternoon. They were milked 3 times per day at 0600, 1400, and 2200 h and milk production was recorded at each milking. Cows were fed individually at 0800 and 1600 h for 5 to 10% refusals and daily DMI was recorded. Body weight was recorded weekly. The FA profile of CaSO (Megalac; Behparvaran Co., Esfahan, Iran), expressed as a percentage of total FA, included 0.1% 12:0, 0.1% 14:0, 10.7% 16:0, 0.3% 16:1, 4.6% 18·0, 29.2% *cis*-9 18:1, 49.6% *cis*-6 18:2, 5.3% *cis*-3 18:3, and 0.1% 20:0.

Sampling

Samples of the total mixed diets were taken weekly, frozen, and pooled on a 4-wk basis. Composited samples were mixed thoroughly and subsampled for chemical analyses. Milk samples were obtained from each cow once per week from the 3 consecutive milkings. Milk samples were pooled to the corresponding milk yield and kept at room temperature (i.e., 23°C) with the preservative potassium dichromate. Fat-corrected milk yield was calculated as (0.4 × kg of milk) + 15(kg of milk × milk fat/100). Energy-corrected milk yield was calculated as (0.327 × kg of milk) + (12.95 × kg of fat) + (7.2 × kg of protein). Estimated energy balance (**EB**) was calculated postpartum for each cow using the following equations from NRC (2001): postpartum EB = net energy of intake − (NE_M + NE_L). Net energy of intake (NE_I) was calculated by multiplying DMI by the calculated net energy value of the diet; $NE_M = 0.08 \times BW^{0.75}$; NE_L = [(0.0929 × % fat) + (0.0547 × % protein) + (0.0395 × % lactose)] × milk production.

Blood was collected from all cows once per wk 3 h after the morning meal from 21 d before the expected calving day until 56 d postpartum. Blood was withdrawn from the jugular vein into Vacutainer tubes (Becton, Dickinson and Co., Franklin Lakes, NJ) containing lithium heparin and immediately put on ice. Tubes were centrifuged at 3,000 × *g* for 20 min at 0°C within 2 h of sampling. The plasma were separated and frozen at −20°C for subsequent analysis.

Chemical Analyses

The DM content of diets was determined by drying at 55°C for 48 h (Sadri et al., 2009). Total mixed dried diets were ground to pass a 1-mm screen in a