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Saturated fat supplementation interacts with dietary forage neutral detergent fiber content during the immediate postpartum and carryover periods in Holstein cows: Production responses and digestibility of nutrients

P. Piantoni, A. L. Lock, and M. S. Allen[1]
Department of Animal Science, Michigan State University, East Lansing 48824

ABSTRACT

Forty-eight multiparous cows were used in a randomized complete block design experiment with a 2 × 2 factorial arrangement of treatments to determine the interaction between a highly saturated free FA supplement (SFFA) and dietary forage neutral detergent fiber (fNDF) content on production responses and nutrient digestibility of dairy cows in the postpartum period. Treatment diets were offered from 1 to 29 d postpartum (postpartum period; PP) and contained 20 or 26% fNDF (50:50 corn silage:alfalfa silage and hay, dry matter basis) and 0 or 2% SFFA [Energy Booster 100 (Milk Specialties Global, Eden Prairie, MN); 96.1% FA: 46.2% C18:0 and 37.0% C16:0]. From 30 to 71 d postpartum (carryover period), a common diet (~23% fNDF, 0% SFFA) was offered to all cows to evaluate carryover effects of the treatment diets early in lactation. During the PP, higher fNDF decreased dry matter intake (DMI) by 2.0 kg/d, whereas SFFA supplementation increased it by 1.4 kg/d. In addition, high fNDF with 0% SFFA decreased DMI compared with the other diets and this difference increased throughout the PP. Treatments did not affect 3.5% fat-corrected milk yield during the PP but did during the carryover period when SFFA supplementation decreased 3.5% fat-corrected milk yield for the low-fNDF diet (51.1 vs. 58.7 kg/d), but not for the high-fNDF diet (58.5 vs. 58.0 kg/d). During the PP, lower fNDF and SFFA supplementation decreased body condition score loss. A tendency for an interaction between fNDF and SFFA indicated that low fNDF with 2% SFFA decreased body condition score loss compared with the other diets (−0.49 vs. −0.89). During the PP, lower fNDF and 2% SFFA supplementation decreased feed efficiency (3.5% fat-corrected milk/DMI) by 0.30 and 0.23 units, respectively. The low-fNDF diet with 2% SFFA decreased feed efficiency compared with other diets early in the PP, but this difference decreased over time. Supplementation of SFFA in the PP favored energy partitioning to body reserves and limited DMI depression for the high-fNDF diet, which might allow higher-fNDF diets to be fed to cows in the PP. However, SFFA supplemented in the low-fNDF diet during the PP affected production negatively in the carryover period. Dietary fNDF and SFFA interacted, affecting performance in the PP with carryover effects when cows were fed a common diet in early lactation.
Key words: dietary forage neutral detergent fiber, early lactation, free fatty acid, postpartum, prilled fat

INTRODUCTION

Following parturition cows enter a period of negative energy balance because they cannot consume enough DM to support lactation. Approaches to increase energy intake of postpartum cows include increasing the energy density of the diet by substituting starch for forage fiber or by fat supplementation. However, because of greater ruminal fermentation from high starch and less buffering from low-forage, high-starch diets might increase the risk of ruminal acidosis and displaced abomasum (Allen and Piantoni, 2013). Different FA, on the other hand, can affect metabolism and animal response differently. For example, unsaturated FA can depress feed intake (Allen, 2000), modulate insulin action (Pires and Grummer, 2008), and alter ruminal biohydrogenation, which can potentially induce milk fat depression (Baumgard et al., 2002) and increase energy partitioning to body reserves (Harvatine and Allen, 2006a; Harvatine et al., 2009). In contrast, SFA are considered to be inert in the rumen (Grummer, 1988), have little effect on DMI (Allen, 2000), and usually increase milk fat output (Wang et al., 2010; Lock et al., 2013; Piantoni et al., 2013). Variation has been observed among responses to FA supplements, and this is likely related to the FA profiles and physical form of the fat supplements, diet composition, and physiological states of cows.

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[1]Corresponding author: allenm@msu.edu

Scant research is available on production responses to diets fed in the postpartum period, especially regarding optimal forage level, fat supplementation, and their interaction. Rabelo et al. (2003) reported that a low forage-to-concentrate ratio (**F:C**) diet (40:60; 25% NDF) fed during the first 20 d postpartum tended to increase DMI (16.5 vs. 15.4 kg/d) and increased calculated energy intake (27.7 vs. 25.1 Mcal/d) compared with a high-F:C diet (60:40; 30% NDF). Beam and Butler (1998) reported that a highly saturated (≥85% saturated) free FA supplemented at 2.6% of diet DM in a 45% forage diet (~33% NDF) decreased yields of milk and 4% FCM during the first 4 wk postpartum and increased them during the following 2 wk on experiment. Importantly, Weiss and Pinos-Rodríguez (2009) reported that the same FA supplement used by Beam and Butler (1998), fed at 2.25% of diet DM from 21 to 126 d postpartum, affected energy partitioning differently depending on forage NDF (**fNDF**) content of the diets. In that experiment, supplemental fat increased BCS with no change in milk yield when supplemented in a 25% fNDF diet (60:40 F:C), but increased milk yield and DMI with no change in BCS when supplemented in a 17% fNDF diet (40:60 F:C).

Although benefits of supplementing a highly saturated free FA to cows in the immediate postpartum period were not identified in the experiment reported by Beam and Butler (1998), the interaction between the same FA supplement and dietary fNDF content reported by Weiss and Pinos-Rodríguez (2009) on energy partitioning in early lactation cows deserves further investigation. Our objectives were to determine the interaction between a highly saturated free FA supplement and dietary fNDF content on yields of milk and milk components, intake, and nutrient digestibility of dairy cows in the postpartum period and to evaluate carryover effects of the treatment diets early in lactation. We hypothesized that the saturated free FA supplement would increase BCS when added to the high-fNDF diet and milk yield when added to the low-fNDF diet during the postpartum period considering results reported by Weiss and Pinos-Rodríguez (2009) with cows in early lactation.

MATERIALS AND METHODS

Animal Housing and Care

All experimental procedures were approved by the Institutional Animal Care and Use Committee at Michigan State University (East Lansing). The experiment began on September 30, 2011, and finished on May 1, 2012. Each cow was housed in the same tiestall, assigned by parturition order, throughout the entire treatment period. Cows were fed once daily (1000 h) at 120 and 110% of expected intake during the treatment and carryover periods, respectively, and milked twice daily (0400 and 1430 h). The amounts of feed offered and orts were weighed for each cow daily. Standard reproduction and health herd checks and breeding practices were maintained during this study.

Design and Treatment Diets

Forty-eight multiparous Holstein cows at the Michigan State University Dairy Field Laboratory were used in a randomized complete block design experiment with a 2 × 2 factorial arrangement of treatments with 12 cows per treatment. Cows were blocked by date of parturition (within 90 d), BCS (up to 1 unit difference using a 5-point scale, where 1 = thin and 5 = fat; Wildman et al., 1982), and previous lactation 305-d mature-equivalent milk production (within 5,500 kg). The BCS used to block cows was the last measurement before parturition. Cows within each block were randomly assigned to treatment on the expected parturition date. Treatment diets were offered from 1 to 29 d postpartum (postpartum period; **PP**). Treatments contained 20 or 26% fNDF and 0 or 2% saturated free FA supplement [**SFFA**; Energy Booster 100 (Milk Specialties Global, Eden Prairie, MN); 96.1% FA: 46.2% C18:0 and 37.0% C16:0]. Desired fNDF content of the treatment diets was attained by altering proportions of forages (alfalfa and corn silages and alfalfa hay) and concentrates (corn grain and soybean meal). Starch content was ~24% for the low-fNDF diets and ~17.5% for the high-fNDF diets, and dietary CP content was held constant across diets. The FA supplement was added at 2% of diet DM, replacing 2% of soyhulls in the 0% SFFA diet. Treatment diets were mixed daily in a tumble mixer and were fed from the morning following parturition. From d 30 to 71 postpartum (carryover period), all cows were offered a common diet, mixed daily in a mixer wagon. The ingredient and nutrient composition of the diets fed as TMR, including a close-up ration for reference, are described in Table 1. All rations were formulated to meet or exceed cows predicted requirements for protein, minerals, and vitamins according to NRC (2001).

Data and Sample Collection

All samples and body measurements were collected or recorded on the same day of the week during the entire experiment (d 5, 12, 19, 26, 33, 40, 47, 54, 61, and 68 postpartum), so all collection days are ±3 d relative to the first day on the treatment diet. Milk yield and feed offered and refused were recorded daily throughout the entire experiment. Samples of all diet ingredients (0.5