J. Dairy Sci. 98:1005–1018
http://dx.doi.org/10.3168/jds.2014-8578

Rapeseed or linseed in dairy cow diets over 2 consecutive lactations: Effects on adipose fatty acid profile and carry-over effects on milk fat composition in subsequent early lactation

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ABSTRACT

During early lactation, milk fatty acid (FA) composition is influenced by diet, animal genetics, and the high availability of preformed FA from body-fat mobilization. Long-term prepartum dietary oilseed supplementation could, therefore, modify milk FA composition postpartum in the subsequent lactation through changes in adipose tissue (AT) FA profile. To test this hypothesis, measurements were made in 19 Holstein cows fed grass-based diets containing no additional lipid (control, CTL; n = 4) or supplemented with extruded linseeds (EL; n = 4), cold-pressed fat-rich rapeseed meal (FRM; n = 6), or whole unprocessed rapeseeds (WR; n = 5) over 2 consecutive lactations (yr 1 and 2) and 2 dry periods. Oilseed supplements were withdrawn from the diets 23 d before the calving of yr 3, following the end of the previous experimental periods in yr 1 to 2. Thereafter, all cows received a total mixed ration composed of grass silage, grass hay, and concentrates (forage:concentrate ratio of 70:30 on a dry-matter basis). Cows previously fed EL and WR had a lower milk fat content (6.32% for CTL and FRM vs. 5.46% for EL and WR) and yield (1.90 kg/d for CTL and FRM vs. 1.61 kg/d for EL and WR) during the first week of lactation. Treatment effects on milk fat content and yield did not persist into lactation wk 3 and 7. Whatever the week, EL and WR increased concentration of FA in milk synthesized de novo (i.e., carbon number ≤15; 17.1 g/100 g of FA for CTL and FRM vs. 22.2 g/100 g of FA for EL and WR) and decreased concentration and secretion of preformed FA (i.e., carbon number ≥17; 56.1 g/100 g of FA for CTL and FRM vs. 49.9 g/100 g of FA for EL and WR). Alterations in milk FA composition may be explained by the lower availability of mobilized FA for uptake by the mammary gland, as indicated by the lower plasma nonesterified FA concentrations for EL and WR compared with CTL and FRM. Prepartum EL feeding increased AT and milk concentration of 18:3n-3 (0.96 vs. 0.79 g/100 g of milk FA for EL and the other groups, respectively) and intermediates of ruminal 18:3n-3 biohydrogenation. In contrast, FRM increased AT and milk concentration of ruminal *cis*-9 18:1 biohydrogenation intermediates. However, EL and FRM supplements resulted in a similar profile of 18-carbon FA isomers in AT (yr 2) and milk (yr 3, 4–10 wk after removing oilseeds from the diet). In conclusion, results confirm that long-term feeding of oilseed supplements alter AT FA composition and may influence milk FA composition during periods of extensive body-fat mobilization such as early lactation.

Key words: dairy cow, oilseed supplementation, carry-over effect, adipose-tissue mobilization, milk fatty acid

INTRODUCTION

The effects of dietary oilseed supplements on bovine milk FA composition have been examined extensively (Chilliard et al., 2007; Ferlay et al., 2013; Shingfield et al., 2013). Feeding oilseeds to lactating cows decreases milk fat 4- to 16-carbon SFA and increases 18:0, *cis*-9 18:1, *trans* FA, and *cis*-9,*trans*-11 CLA concentrations. Such changes in milk FA composition may potentially influence the incidence of several chronic human diseases (Shingfield et al., 2008; Givens, 2010). During early lactation, dairy cows experience negative energy balance and extensive body-fat mobilization. At the same time, milk fat concentration of FA synthesized de novo is lower, and the content of preformed FA is

Received July 7, 2014.
Accepted October 22, 2014.
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higher, compared with mid or late lactation (Palmquist et al., 1993). Thus, the profile of preformed 18:1, 18:2, and 18:3 isomers in milk fat during early lactation partially reflects the FA composition of adipose tissue (**AT**; Chilliard et al., 2000). Furthermore, FA composition of AT in dairy cows is known to be altered by duodenal infusion of rapeseed oil in periods of positive energy balance during mid lactation but not during early lactation when energy balance is negative and extensive body-fat mobilization is used to support milk production (Chilliard et al., 1991).

Investigations on the carry-over effects of lipid supplementation on milk fat composition in the subsequent lactation are limited to studies examining the role of oilseeds fed during 5 to 7 wk prepartum (Morel et al., 2008; Santschi et al., 2009; Leiber et al., 2011). Supplementing with processed linseeds resulted in marginal increases in 18:3n-3 concentration of colostrum 1 or 2 d postpartum (Santschi et al., 2009; Leiber et al., 2011), whereas sunflower seeds caused a minor increase of 18:2n-6 in milk during the first week of lactation (Morel et al., 2008). We hypothesize that the relatively short duration of oilseed supplementation prepartum in these studies was insufficient to change the FA profile of AT and that a longer exposure to oilseed supplements would induce larger effects on AT FA composition, and thereby influence milk FA composition early postpartum in the subsequent lactation. The objective of this study was to assess whether long-term oilseed supplementation would alter AT FA profile in lactating cows and cause residual carry-over effects on milk FA composition during the beginning of the subsequent lactation.

MATERIALS AND METHODS

Animals and Diets

All experimental procedures were conducted in accordance with the French guidelines for experimental animal use. Fifty-eight dairy Holstein cows were recruited to a long-term experiment (Figure 1) and fed a control diet or a similar diet supplemented with processed oilseeds over 2 consecutive lactations. Details of the experimental design have been reported elsewhere (Lerch et al., 2012a,b,c). On completion of the second lactation of the experiment, only 19 out of the 58 cows initially recruited to the study were available during the beginning of the subsequent lactation, which was mostly because of reproduction problems. Those cows had been on one of the following experimental treatments during yr 1 and 2: control (**CTL**, 4 cows), extruded linseeds (**EL**, 4 cows), cold-pressed fat-rich rapeseed meal (**FRM**, 6 cows), or unprocessed whole rapeseeds (**WR**, 5 cows). Oilseed supplements were withdrawn 3 wk before calving to investigate possible carry-over effects on milk FA composition early postpartum.

During yr 1 and 2 of the experiment, cows received grass-based diets containing no additional lipid or supplemented with oilseed by-products. The control concentrate comprised pelleted wheat and solvent-extracted rapeseed meal (CTL), which was partially substituted by EL [extruded blend of linseeds and wheat (70:30, wt/wt); INZO°, Argentan, France], FRM (by-product of rapeseed oil extraction by cold pressure; Dock Moulin SA, Marneffe, Belgium), or WR (INZO°). For EL, FRM, and WR, oilseed supplements provided a minimum of 2.5% and a maximum of 5.1% of oil in diet DM (mean values of 2.9, 3.1, and 3.3% for EL, FRM, and WR, respectively, over the 2 yr of the supplementation period). By design, cows received experimental treatments until the end of yr 2 of the experiment (26 ± 9 d before calving in yr 3), which corresponded to 732 ± 40 d (mean ± SD) of oilseed supplementation. Thereafter, experimental concentrates were progressively removed from the diet over a period of 3 d. From 23 ± 9 d (mean ± SD) before calving, all 19 cows received a similar control diet containing no oilseed

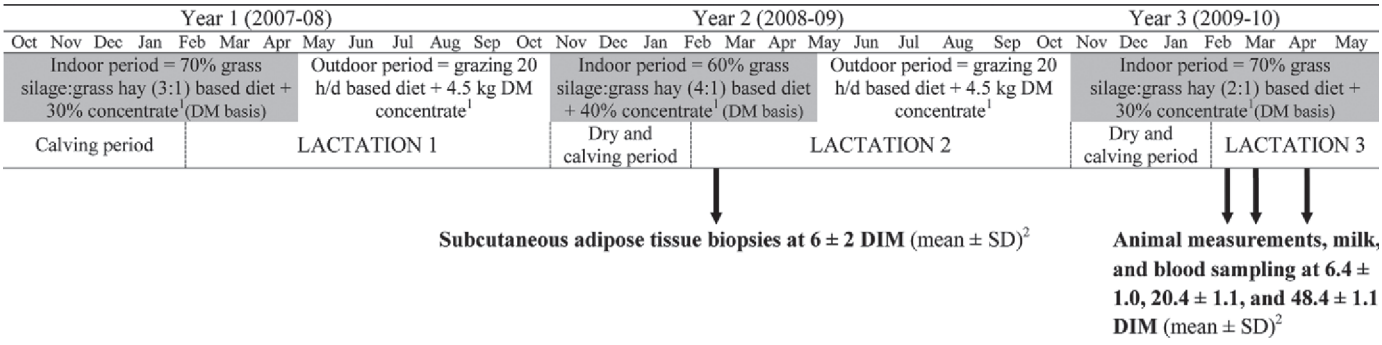

Figure 1. Summary of the experimental design used in study yr 1 to 3. [1]From wk 6 of lactation in yr 1, until 23 ± 9 d (mean ± SD) before calving in yr 3, concentrates contained no additional lipid (control) or oilseed supplements (extruded linseeds, cold-pressed fat-rich rapeseed meal, and whole unprocessed rapeseeds; Lerch et al., 2012a). Thereafter, all cows received the control concentrate until 49 d postpartum into the third lactation. [2]Timing relative to measurement and sampling initiated at the onset of lactation in yr 2 and 3.