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Short communication: Effects of lysolecithin on milk fat synthesis and milk fatty acid profile of cows fed diets differing in fiber and unsaturated fatty acid concentration

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ABSTRACT

Thirteen multiparous Holstein cows were used in a crossover design that tested the effect of lysolecithin in diets differing in neutral detergent fiber (NDF) and unsaturated fatty acid (FA) concentrations. Experimental periods were 20 d in length and included two 10-d phases. A standard fiber and lower fat diet was fed the first 10 d (30.5% NDF, no added oil, lower-risk phase) and a lower NDF and higher oil diet was fed during the second 10 d (29.0% NDF and 2% oil from whole soybeans and soybean oil, high-risk phase). Treatments were control and 10 g/d of lysolecithin (LYSO) extended in a ground corn carrier. Milk was sampled on d 0, 5, and 10 of each phase for determination of fat and protein concentration and FA profile. We found no effect of treatment or treatment by time interaction for dry matter intake, milk yield, or milk protein concentration. A treatment by time interaction was observed for milk fat concentration and yield. Milk fat concentration was higher in LYSO on d 5 of the lower-risk phase, but decreased progressively in both treatments during the high-risk phase. Milk fat yield was not different among treatments during the lower-risk phase, but was lower in LYSO on d 15 and tended to be lower on d 20 during the high-risk phase. Concentrations of milk de novo FA decreased and preformed FA increased during the high-risk phase, but we found no effect of treatment or treatment by time interactions. We noted an effect of time, but no treatment or treatment by time interactions for milk *trans* FA isomers. Briefly, *trans*-11 C18:1 and *cis*-9,*trans*-11 conjugated linoleic acid progressively decreased as *trans*-10 C18:1 and *trans*-10,*cis*-12 conjugated linoleic acid progressively increased during the high-risk phase. The LYSO increased milk fat concentration when feeding a higher fiber and lower unsaturated FA diet, but decreased milk fat yield when feeding a lower fiber and higher unsaturated FA diet, although biohydrogenation pathways and capacity did not appear to be modified. The effect of lysolecithin on rumen fermentation warrants further investigation, but is not recommended when feeding lower fiber and higher unsaturated fat diets.

Key words: emulsifier, lysolecithin, milk fat, biohydrogenation

Short Communication

Biohydrogenation (**BH**)-induced milk fat depression (**MFD**) is a specific reduction in milk fat yield, with no concurrent change in milk or milk protein yield, commonly observed in cows fed low-fiber or high-UFA diets (Bauman and Griinari, 2001). These factors cause alterations in the ruminal BH pathway of UFA, resulting in increased production of bioactive BH intermediates such as *trans*-10,*cis*-12 CLA, which are potent inhibitors of mammary lipid synthesis (Bauman and Griinari, 2001). Following dietary modifications, alternate biohydrogenation pathways and MFD can be observed within 7 to 10 d (Shingfield et al., 2006, Rico and Harvatine, 2013) and are closely associated with modifications in the ruminal microbial population (Weimer et al., 2010, Azad et al., 2015, Rico et al., 2015).

Emulsifiers are amphiphilic substances capable of mixing lipids and water. Dietary inclusion of an emulsifier, such as Tween 80, has been shown to increase enzymatic activity (Lee and Ha, 2003, Kim et al., 2004), enhance VFA production (Chen et al., 2011), and increase the digestibility of fiber and of other nutrients (Kim et al., 2004) in in vitro fermentation systems.

Lysolecithin is a very potent emulsifier derived from enzymatic hydrolysis of lecithin. It is naturally produced in the small intestine of the cow through phospholipase A2 hydrolysis of lecithin and aids in digestion of fatty acids (**FA**); it is also produced to a lesser extent in the rumen from degradation of feed phospholipids,

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but is also degraded by rumen microorganisms (Dawson, 1959). Importantly, lysolecithin has been shown to improve feed efficiency and growth in nonruminants (Schwarzer and Adams, 1996), presumably through improved digesta emulsification or modification of gut physiology (Brautigan et al., 2017). Lysolecithin has the potential to affect rumen fermentation as an emulsifier; for example, by increasing substrate-enzyme interaction. Furthermore, an interaction with dietary fat is expected, as lysolecithin is expected to increase emulsification of FA, making them more available for biohydrogenation as well as increase their passage through association with the liquid phase.

Our objective was to investigate the effect of lysolecithin in diets with lower and higher risk for BH-induced MFD (i.e., diets differing in PUFA and fiber). We hypothesized that lysolecithin would reduce the occurrence and extent of MFD and associated BH intermediates when feeding diets with increasing risk of MFD by increasing FA emulsification and increasing BH and passage rates.

Thirteen noncannulated, postpeak (132 ± 42 DIM; mean ± SD) multiparous Holstein cows from the Pennsylvania State University Dairy Research Center were used. All experimental procedures were approved by the Pennsylvania State University Institutional Animal Care and Use Committee. Cows were randomly assigned to treatment sequences in a crossover design that tested increasing 2 levels of UFA and NDF during 2 experimental phases. The first 10 d, a higher-fiber and lower-UFA diet was fed (30.5% NDF, no added oil, lower-risk phase); the second 10 d, a lower-NDF and higher-UFA diet was fed (29% NDF and 2% oil from whole soybeans and soybean oil, high-risk phase). A 14-d washout period allowed recovery of normal ruminal BH and milk fat yield between experimental periods. Treatments were control and lysolecithin (**LYSO**; 10 g/d per cow of lysolecithin from Lysoforte, Kemin Industries, Des Moines, IA). Lysolecithin was extended in a ground corn carrier and added in a small batch vertical TMR mixer. We were not aware of previous work with lysolecithin in ruminants, so the dose was based on work in nonruminants (e.g., Schwarzer and Adams, 1996; Melegy et al., 2010). The control diet was fed for 7 d before initiation of the experiment. Cows were fed once daily at 110% of expected intake and milked twice daily in a milking parlor. Milk yield was measured by an integrated milk meter (AfiMilk, SAE Afikim, Afikim, Israel). The parlor stalls were calibrated weekly using data from the entire herd (>200 cows) over 7 d. Stall adjustments were determined by modeling the effect of day, milking (a.m./p.m.), cow, and stall, excluding observations of experimental cows during treatment periods. Milk was sampled the day before the start of the experiment, at the end of the washout period, and d 5 and 10 of each dietary phase. All milk samples were analyzed for fat and true protein by infrared spectroscopy by Dairy One (State College, PA). Additionally, samples were composited within day by milk yield before determination of FA profile by GC, as described by Rico and Harvatine (2013). Briefly, milk triglycerides were extracted in hexane:isopropanol and then base-methylated. The temporal interaction of lysolecithin and dietary risk factors was analyzed using the repeated measures statement of PROC MIXED (version 9.3, SAS Institute Inc., Cary, NC). The model included the random effect of sequence, cow nested in sequence, and period, and the fixed effects of treatment, time, and their interaction. The autoregressive [AR(1)] or heterogeneous autoregressive [ARH(1)] covariance structures were used depending on model fit based on the Schwartz Bayesian criterion. Preplanned contrast tested the effect of treatment at each time point.

Experimental diets contained corn silage, mixture of grass hay and straw, ground corn, canola meal, cottonseed hulls, roasted soybeans, encapsulated urea, and a vitamin and mineral supplement (Supplemental Table S1; https://doi.org/10.3168/jds.2017-12976). The diet fed during the high-risk phase contained an additional 1.5 percentage units of whole soybeans and 1.3 percentage units of soybean oil and was 1.5 percentage units lower in NDF. Consequently, total FA and C18:2 n-6 content were increased by 44 and 66% compared with the low-risk phase, respectively. The lower-risk diet contained 17.6% CP, 30.5% NDF, 28.6% starch, and 3.45% total FA, and the high-risk diet contained 17.8% CP, 29.0% NDF, 29.3% starch, and 4.98% total FA. As expected, the reduction in NDF while increasing oil content in the high-risk ration resulted in induction of modest BH-induced MFD. Briefly, a progressive decrease in milk fat concentration and yield occurred in both treatments during the high-risk phase, although it was more pronounced for the LYSO treatment. This coincided with a reduction in the proportions of de novo and 16C FA, whereas preformed FA concentration increased. Additionally, intermediates of the normal pathway of BH (*trans*-11 C18:1 and *cis*-9,*trans*-11 CLA) peaked on d 15 during the high-risk phase and the concentrations of FA in the alternate BH pathway (*trans*-10 C18: and *trans*-10,*cis*-12 CLA) progressively increased in both treatments, similar to the shift in BH pathways during BH-induced MFD previously reported (Shingfield et al., 2006; Rico and Harvatine, 2013).

We observed no effect of treatment or treatment by time interaction on DMI or milk yield, but a treatment by time interaction occurred for milk fat yield and concentration (Figure 1). Milk fat concentration was higher in LYSO than in control on d 5 during the