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Ruminal fermentation, milk fatty acid profiles, and productive performance of Holstein dairy cows fed 2 different safflower seeds[1]

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ABSTRACT

A lactation trial was conducted to determine the effects of supplementing whole safflower seeds (SS) on ruminal fermentation, lactational performance, and milk fatty acid (FA) profiles. Nine multiparous Holstein cows (days in milk = 110 ± 20) were used in a replicated 3 × 3 Latin square design. Each period lasted 21 d, with 14 d of adaptation and 7 d of data collection. Within square, cows were randomly assigned to a sequence of 3 dietary treatments as follows: cottonseed total mixed ration (TMR; CST), conventional SS (variety S-208) TMR (CSST), and NutraSaff SS (Safflower Technologies International, Sidney, MT) TMR (NSST). Diets contained approximately 63% forage (36% alfalfa hay, 4% grass hay, and 23% corn silage) and 37% concentrate supplemented with 2% cottonseed to the CST and 3% conventional or NutraSaff SS to the CSST or the NSST, respectively. Intake of dry matter (DM) averaged 21.8 kg/d and did not differ across diets, but feeding the NSST decreased intake of neutral detergent fiber (NDF) due to lower dietary concentration of NDF in the NSST. Digestibilities of DM and nutrients were similar among treatments. No differences in yields of milk or milk components were observed in response to supplementing SS. Dietary treatments did not affect ruminal pH, total or molar proportions of ruminal volatile FA, and ammonia-N. However, cows fed SS had a higher molar proportion of isobutyrate than those fed the CST diet. Ruminal C16:0 FA concentration increased with the CST, whereas C18:1 *cis*-9 and C18:2 n-6 tended to increase with SS supplementation, indicating that conventional and NutraSaff SS were partially protected from microbial biohydrogenation. Supplementing SS decreased milk C16:0 concentration, whereas it increased C18:1 *cis*-9 and C18:1 *trans*-9. Milk FA C18:1 *trans*-11 and *cis*-9, *trans*-11 conjugated linoleic acid increased and tended to increase with feeding the NSST, respectively, but not the CSST diet. In conclusion, supplementing diets with whole SS at 3% of dietary DM can be an effective strategy of fat supplementation to lactating dairy cows without negative effects on lactational performance and milk FA profiles.

Key words: safflower seed, ruminal fermentation, milk fatty acid, lactational performance

INTRODUCTION

Addition of fats in lactating dairy cow diets allows for the maintenance of energy density while increasing fiber intake, resulting in stabilization of ruminal fermentation (Allen, 1997). In addition, a fat supplement that maximizes DMI and ruminal fiber digestion increases milk production and milk component yield, and improves health and reproduction of dairy cows (Overton and Waldron, 2004). The need for various fat sources that are digestible in the small intestine, easy to use, and cost-effective has drawn a lot of attention with the increasing costs of ration ingredients. In the western and central United States, safflower (*Carthamus tinctorius* L., Asteraceae) has been widely grown because of tolerance to hot and dry climates (Li and Mündel, 1996; Bradley et al., 1999). Safflower seed (**SS**) is usually 106% higher in fat and 21% lower in CP than is whole linted cottonseed (**CS**; Dschaak et al., 2010). The high oil concentration of SS makes it an attractive energy-dense feed for animals with high energy requirements, such as lactating dairy cattle. Alizadeh et al. (2010) reported that SS can be included up to 5% of dietary DM alongside CS for early lactating cows without affecting feed intake while maintaining normal ruminal fermentation, peripheral energy supply, and milk production. We recently conducted a lactation study to assess productive performance of dairy cows fed varying levels of whole NutraSaff SS (**NSS**), a new variety of SS (Safflower Technologies International, Sidney, MT) containing higher oil and lower fiber concentrations than traditional SS varieties (Bergman et al., 2007). The study demonstrated that NSS can replace CS and

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be fed to lactating dairy cows without negative effects on lactational performance up to 3% DM (Dschaak et al., 2010). Feeding the NSS improved efficiency of use of feed N to milk N and decreased MUN; however, how feeding the SS affects ruminal fermentation and FA profiles has not been assessed.

In addition to the benefits on nutrient utilization, feeding NSS enhanced functional quality of milk with increased *cis-9*, *trans-11* conjugated linoleic acid (**CLA**) concentration, which is an additional benefit to human health (Dschaak et al., 2010). However, the beneficial effect of NSS was counterbalanced by an unfavorable increase of *trans-10* 18:1 fatty acid (**FA**). Many dietary treatments producing high levels of CLA also induce a shift in the major biohydrogenation (**BH**) pathways characterized by increased accumulation of *trans-10* and *trans-11* 18:1 FA. The increase in the *trans-10* 18:1 content of milk fat is indicative of complex changes in ruminal BH pathways (Lock et al., 2007). Therefore, further research is needed to identify if other CLA isomers or 18:1 *trans* FA would be involved to affect milk fat yield when SS are fed in lactating dairy cow diets.

We hypothesized that supplementation of SS in the lactating dairy cow diet would improve nutrient utilization and milk FA profiles, but a conventional SS (**CSS**) and NSS elicit different milk FA profiles due to their unique FA compositions. Our objective was to assess lactational performance, ruminal fermentation, and milk FA profiles and their effects on milk fat yield when dairy cows were fed CSS or NSS.

MATERIALS AND METHODS

The dairy cows used in this study were cared for according to the Live Animal Use in Research Guidelines of the Institutional Animal Care and Use Committee at Utah State University (Logan).

Cows, Experimental Design, and Diets

Nine multiparous lactating Holstein cows were used; 3 cows were surgically fitted with ruminal cannula, and they consisted of 1 of 3 squares. Days in milk ranged from 70 to 108 and from 100 to 144 for noncannulated and cannulated cows, respectively, at the start of the experiment. Average BW was 656 ± 130.9 kg at the beginning of the experiment and 705 ± 123.3 kg at the end of the experiment.

The design of the experiment was a replicated 3 × 3 Latin square, with each period lasting 21 d (14 d of treatment adaptation and 7 d of sampling and data collection). The 3 squares were conducted simultaneously. Within square, cows were randomly assigned to a sequence of 3 dietary treatments consisting of CS TMR without whole SS (**CST**), CSS TMR (**CSST**), and NSS TMR (**NSST**; Table 1). The CSS (variety S-208) is a normal white hull seed cultivar and a linoleic oil variety, containing 37.6% ether extract and 42.2% NDF, whereas the NSS contains higher oil (45.8% ether extract) and lower fiber concentration (23.7% NDF) than CSS (Table 2). The diets had approximately 63.0% forage and 37.0% concentrate. The CSS and NSS added to the CSST and NSST diets replaced whole linted CS in the CST diet, and Table 1 shows the diet composition. In our previous study (Dschaak et al., 2010), efficiency of use of feed N to milk N increased by feeding NSS, and we speculated that N solubility of NSS may be lower than that of CS, thereby influencing ruminal ammonia production and, consequently, MUN concentration. Although N utilization was not our primary interest in the current study, we would assess N fermentation in the rumen when SS was supplemented. In addition, Dschaak et al. (2010) reported that milk fat concentration was greatly affected when NSS was included at 4% DM with a 15% reduction, and at the inclusion rate increase of 18:1 *trans*-10 milk FA, was much more pronounced compared with lower inclusion rates of NSS. These findings indicate that inclusion of SS more than 3% DM may induce complex changes in ruminal BH pathways and cause diet-induced milk fat depression. Consequently, the CSS and the NSS were added at 3.0 and 3.1% DM, respectively, to formulate isonitrogenous diets and avoid possible negative effects of feeding SS on milk fat yield. Diets were formulated based on NRC (2001) recommendations to provide sufficient NE_L, metabolizable protein, vitamins, and minerals to produce 35 kg of milk/d with 3.5% fat and 3.0% true protein.

Cows were housed in individual tie-stalls fitted with rubber mattresses, bedded with straw, and were fed a TMR for ad libitum intake with at least 10% of daily feed refusal. All cows were individually fed twice daily at 0830 and 1500 h with approximately 70 and 30% of total daily feed allocation at each feeding, respectively. Feed offered and refused was recorded daily, and daily samples were collected to determine DMI. Cows had free access to water.

Cows were milked twice daily at 0400 and 1600 h. Milk production was recorded daily throughout the experiment. Cows were turned outside to a dry lot for exercise for at least 1 h daily in the morning after being milked. Milk was sampled during the a.m. and p.m. milkings on 2 consecutive days (d 16 and 17) in each period. Individual milk samples were analyzed for fat, true protein, lactose, and MUN by the Rocky Mountain DHIA Laboratory (Logan, UT). Milk composition was expressed on weighted milk yield of a.m. and p.m. samples. Yields of milk fat, true protein, and lactose were