J. Dairy Sci. 97:5088–5100
http://dx.doi.org/10.3168/jds.2013-7653

Effects of feeding lauric acid or coconut oil on ruminal protozoa numbers, fermentation pattern, digestion, omasal nutrient flow, and milk production in dairy cows[1]

A. P. Faciola*[2] and G. A. Broderick†
*Department of Agriculture, Nutrition, and Veterinary Science, University of Nevada, Reno 89557
†United States Dairy Forage Research Center, Agricultural Research Service, USDA, Madison, WI 53706

ABSTRACT

The objectives of this study were to evaluate the feeding of coconut oil (CO), in which lauric acid (La) comprises about 50% of the fatty acid composition, as a practical rumen protozoa (RP) suppressing agent, to assess whether the source of La affects ruminal fermentation and animal performance and to test whether suppressing RP improves N utilization, nutrient digestion, nutrient flow at the omasal canal, and milk production. Fifteen multiparous Holstein cows (3 fitted with ruminal cannulas) and 15 primiparous Holstein cows (3 fitted with ruminal cannulas) were used in a replicated 3 × 3 Latin square experiment with 14 d of adaptation and 14 d of sample collection. Diets were fed as total mixed ration and contained (dry matter basis) 10% corn silage, 50% alfalfa silage, and 40% concentrate. The control diet contained 3% (dry matter basis) calcium soaps of palm oil fatty acids (Megalac, Church & Dwight Co. Inc., Princeton, NJ) as a ruminally inert fat source and had no added La or CO. Diets with La and CO were formulated to contain equal amounts of La (1.3%, dry matter basis). Dry matter intake was not affected by treatment. Both CO and La reduced RP numbers by about 40%. Lauric acid reduced yield of milk and milk components; however, CO did not affect yield of milk and yields of milk components. Both La and CO caused small reductions in total VFA concentration; CO increased molar proportion of ruminal propionate, reduced ruminal ammonia and branched-chain volatile fatty acids, suggesting reduced protein degradation, and reduced milk urea N and blood urea N concentrations, suggesting improved protein efficiency. Lauric acid reduced total-tract apparent digestibility of neutral detergent fiber and acid detergent fiber as well as ruminal apparent digestibility of neutral detergent fiber and acid detergent fiber as measured at the omasal canal; however, CO did not alter fiber digestion. Microbial protein flow at the omasal canal, as well as the flow of N fractions at the omasal canal, did not differ among treatments. Results from this experiment have confirmed that dietary La is not a practical agent for suppressing RP population in dairy cows, mainly because of its negative effects on fiber digestion and ruminal fermentation. Intake of CO appeared to reduce ruminal and improve protein efficiency, but did not improve milk production, milk composition, or increase microbial outflow from the rumen. Based on the results of this study, a 40% reduction of RP population is not sufficient to improve N utilization in dairy cows.
Key words: coconut oil, dairy cow, protozoa

INTRODUCTION

Protein is an expensive dietary nutrient; furthermore, excessive excreted N is an important environmental concern. Therefore, improving N utilization is a major challenge in ruminant nutrition research. The main sources of AA for ruminant animals are the microbial protein synthesized in the rumen and RUP; however, according to Jouany (1996), ruminal protozoa (**RP**) have a negative effect on protein utilization in ruminants because they reduce ruminal outflow of both microbial protein and RUP. Moreover, RP are the main contributors to bacterial protein turnover in the rumen (Wallace and McPherson, 1987), which is a consequence of RP predation on bacteria. Rumen protozoa possess protease (Forsberg et al., 1984), peptidase (Newbold et al., 1989), and deaminase (Itabashi and Kandatsu, 1975) activity; therefore, they actively degrade proteins, peptides, and AA, producing large amounts of ruminal ammonia, which they cannot completely use, therefore contributing to urinary urea excretion.

Medium-chain FA, such as lauric acid (**La**; C12:0), have been shown to have potent antiprotozoal effects (Newbold and Chamberlain, 1988; Hristov et al., 2011; Faciola and Broderick, 2013). Furthermore, they may

Received October 29, 2013.
Accepted May 5, 2014.
[1]Mention of any trademark or proprietary product in this paper does not constitute a guarantee or warranty of the product by the USDA or the Agricultural Research Service and does not imply its approval to the exclusion of other products that also may be suitable.
[2]Corresponding author: afaciola@cabnr.unr.edu

be used routinely in farm operations and may have the potential to replace hazardous antiprotozoal chemicals.

Although suppression of RP may have the potential to improve N utilization in the rumen, achieving the level of RP suppression that would allow such improvement is still a challenge. Faciola et al. (2013) observed a strong antiruminal protozoa activity of La when a single dose of 160 g/d was given via ruminal cannula, reducing RP by 90% within 2 d of treatment. However, when La was fed at 160 and 240 g/d in the TMR, RP were reduced by only 25 and 30%, respectively, showing that these amounts mixed in the diet were not sufficient to suppress RP effectively. In a subsequent study, Faciola and Broderick (2013) tested greater doses of La in the TMR (240, 480, and 720 g/d), aiming to determine the dietary amount of La that would effectively suppress RP. These amounts reduced RP by 28, 50, and 64%, respectively; however, the 2 highest amounts also drastically reduced DMI and impaired ruminal fermentation and, consequently, decreased milk production. It has been speculated that high doses of La may affect diet palatability (Hristov et al., 2011). Coconut oil (**CO**), in which La comprises about 50% of the FA composition, may be an alternative to feeding La because it may not have the same negative effects on DMI and ruminal fermentation (Faciola and Broderick, 2013). Therefore, the main goal of the present study was to evaluate dietary CO as a practical RP-suppressing agent and to test whether suppressing RP improves N utilization, nutrient digestibility, nutrient flow at the omasal canal, as well as milk composition and production. We hypothesized that CO would suppress RP numbers without depressing DMI and ruminal fermentation, thereby improving N utilization and milk production.

MATERIALS AND METHODS

Care and handling of all experimental animals, including ruminal cannulation, were conducted under protocols approved by the University of Wisconsin Institutional Animal Care and Use Committee. Fifteen multiparous Holstein cows (3 fitted with permanent ruminal cannulas), averaging 2.5 ± 0.9 parity, 71 ± 39 DIM, 39.8 ± 3.7 kg/d of milk, and 621 ± 60 kg BW, and 15 primiparous Holstein cows (3 fitted with permanent ruminal cannulas), averaging 123 ± 53 DIM, 36.3 ± 4 kg/d of milk, and 545 ± 62 kg BW at the beginning of the study, were blocked by parity and by DIM within parity into 10 squares of 3 cows (2 squares of cannulated cows). Cows were randomly assigned within squares to 3 balanced dietary treatment sequences [i.e., with each diet following every other diet twice in each pair (multiparous and primiparous) of squares over the trial] in a replicated 3 × 3 Latin square with 14 d of adaptation and 14 d of sampling.

Composition of the fermented feeds fed is in Table 1. Diets were fed as a TMR and contained (DM basis) 10% corn silage, 50% alfalfa silage, and 40% concentrate (Table 2). The control diet contained calcium soaps of palm oil FA (Megalac, Church & Dwight Co. Inc./Arm & Hammer Animal Nutrition, Princeton, NJ) as a ruminally inert fat source with no added La (99% La, KIC Chemicals Inc., Armonk, NY) or CO (Columbus Food Inc., Chicago, IL). The calcium soaps of palm oil FA, La, and CO were first thoroughly mixed with ground shelled corn and then mixed with the other concentrate ingredients before being mixed with the forages and fed as TMR. Both control and CO diets had the same ether extract content. Diets La and CO were formulated to contain equal amounts of La (1.3% on a DM basis), either as La (diet La) or in the form of coconut oil (diet CO).

All cows were injected every other week with bovine somatotropin (500 mg of Posilac, Elanco Animal Health, Greenfield, IN) from about 60 DIM; injections were synchronized such that animals received a full dose on d 1 and at 14-d intervals throughout the trial. Cows were housed in tiestalls and had free access to water during the trial.

Diets were offered once daily at 1000 h. Orts were collected and weights recorded at 0900 h and feeding rate was adjusted daily to yield orts of about 5 to 10% of intake. Weekly composites of corn silage, alfalfa silage, high-moisture shelled corn, TMR, and orts were taken from daily samples of about 0.5 kg that were stored at −20°C. Weekly samples were also taken of ground corn grain and solvent-extracted soybean meal and stored at room temperature. The DM was determined in weekly composites of corn silage, alfalfa silage, and rolled high-moisture shelled corn by drying at 60°C for 48 h and in weekly samples of ground corn grain and solvent-extracted soybean meal at 105°C, according to AOAC (1980). Weekly samples of feed ingredients were also analyzed for total N using a combustion assay (Leco FP-2000 N Analyzer, Leco Instruments Inc., St. Joseph, MI). Ingredient DM and N contents were used to adjust dietary composition weekly to maintain constant DM proportions from each feed ingredient and equal CP contents in each diet. Intake of DM was computed based on the 60°C DM determinations for TMR and orts. After drying, ingredients and TMR were ground through a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA). Samples were analyzed for total N (Leco FP-2000 N Analyzer, Leco Instruments Inc., St. Joseph, MI); DM at 105°C; ash and OM by AOAC (1980) methods; sequentially for NDF and ADF; and