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Effect of dietary supplementation with heat-treated canola meal on ruminal nutrient metabolism in lactating dairy cows

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ABSTRACT

An experiment was conducted to quantify the effects of incremental levels of heat-moisture-treated canola meal (TCM) fed to dairy cows on the relationship between ruminal nutrient digestion and milk production. Experimental diets were fed to 4 multiparous rumen-cannulated Nordic Red cows, averaging (mean ± standard deviation) 681 ± 54.8 kg of body weight, 111 ± 16 d in milk, and 29.1 ± 9.1 kg of milk/d at the start of the study, in a Latin square design with four 21-d periods. The 4 experimental dietary treatments consisted of a basal diet of grass silage and crimped barley, and 3 diets in which the crimped barley was replaced with TCM, giving 3 incremental levels of protein supplementation. Nutrient flow was quantified by the omasal sampling technique using 3 markers (Cr, Yb, and indigestible neutral detergent fiber). Continuous infusion of ^{15}N was used to label bacterial crude protein. Additionally, ruminal sampling and evacuations and measurements of total-tract digestibility were conducted. The experimental diets provided 132, 148, 164, and 180 g of crude protein/kg of dry matter. The increased level of TCM linearly increased dry matter intake from 15.1 to 16.6 kg/d and energy-corrected milk yield from 21.0 to 25.6 kg/d. The increased proportion of TCM when substituting barley with TCM was associated with greater total-tract digestibility of neutral detergent fiber and potentially digestible neutral detergent fiber, which could be explained by increased digestion rate of potentially digestible neutral detergent fiber. Omasal flow of nonammonia N naturally increased with greater dietary TCM inclusion, but the increased intestinal supply of rumen-undegradable protein was partly offset by diminished microbial protein synthesis when feeding more TCM. This was also reflected in a decreased proportion of milk protein from ruminal bacterial protein when TCM supplementation increased.
Key words: canola meal, dairy cow, microbial protein, milk protein

INTRODUCTION

Feeding protein supplements represents a significant cost to the dairy farm, but is still advantageous because of the positive response in milk production. Although increasing dietary CP concentrations increases milk yield, there is an environmental concern due to substantially decreased milk N efficiency (Broderick, 2003; Ipharraguerre and Clark, 2005). Reducing the rumen degradability of protein supplements is a strategy applied to increase the supply of dietary AA to the small intestine. This concept assumes improved milk production from increased AA supply to the lactating dairy cow. However, the relevance of this concept can be questioned, despite an aim to also improve N utilization efficiency. Santos et al. (1998) found increased milk production in only 17% of comparisons between soybean meal (**SBM**) and supplements with a high concentration of RUP. In similar comparisons, Ipharraguerre and Clark (2005) found small differences (−2.5 to +2.8%) in milk yield between feeding solvent-extracted SBM and other protein supplements high in RUP. Furthermore, following a meta-analysis of large North European and North American data sets, Huhtanen and Hristov (2009) concluded that ruminal CP degradability (according to NRC, 2001) is not an important factor in predictions of milk protein yield or milk N efficiency.

Several reasons are possible for the moderate production responses observed with increased RUP concentration of protein supplements when fed to dairy cows. Feeding more RUP increases the amount of nonammonia, nonmicrobial N (**NANMN**) that is available for absorption in the small intestine, but can instead decrease the amount of rumen microbial NAN (Clark et al., 1992). Ipharraguerre and Clark (2005) found a 7% decrease in passage of microbial NAN to the small intestine with increased RUP supplementation. Further-

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more, it could be speculated that any treatment that reduces the ruminal degradability of a feed could also make some AA unavailable to the cow, due to Maillard reactions between AA and carbohydrates in the heating process (Van Soest, 1994). For example, heat treatment of canola meal has been shown to decrease the concentration of Lys (Moshtaghi Nia and Ingalls, 1995; Dakowski et al., 1996). A third reason for the lack of production response with increased RUP supplementation could be due to the discrepancy between RUP predictions and in vivo results. Broderick et al. (2010) found that RUP estimated with the NRC (2001) model overestimated the flow of NANMN by 26% and underestimated microbial NAN flow compared with measurements using the omasal sampling technique in cannulated lactating dairy cows. They suggest that the overestimation might be due to errors from using the in situ technique, which assumes that the soluble protein fraction is completely degraded.

In Northern Europe, where grass silage is the foundation of dairy cow diets, canola meal has shown greater potential than SBM to increase milk production (Shingfield et al., 2003; Gidlund et al., 2015). The hypothesis in the present study was that increased flow of NANMN to the omasum with increased amount of solvent-extracted, heat-moisture-treated canola meal (**TCM**) could be at the expense of reduced microbial NAN flow. To test this hypothesis, the supply of CP was increased by gradually replacing crimpled barley with TCM. Feeding incremental levels of TCM allowed in-depth study of the effects of CP supplementation in typical dairy cow diets in Northern Europe, in relation to ruminal digestion and microbial protein synthesis, and the origin of the N incorporated into milk protein.

MATERIALS AND METHODS

All animals were registered and cared for according to guidelines approved by the Swedish University of Agricultural Sciences Animal Care and Use Committee and the National Animal Research Authority, and the experiment was carried out in accordance with the laws and regulations controlling experiments performed with live animals in Sweden.

Animal Management, Experimental Design, and Diets

This experiment used 4 multiparous lactating Nordic Red cows, averaging (mean ± SD) 681 ± 54.8 kg of BW, 111 ± 16 DIM, and 29.1 ± 9.1 kg of milk/d at the start of the study. All cows were fitted with a 10-cm ruminal cannula (Bar Diamond, Inc., Parma, ID). The cows were housed in tie-stalls bedded with sawdust, had free access to water and salt blocks throughout the experiment, and were offered feed twice daily, at 0600 and 1800 h. Orts were recorded once daily and feeding rate was adjusted to yield orts of approximately 10% of intake, except during the 4 d of sampling from the omasum when intake was restricted to 95% of ad libitum intake to minimize between- and within-day variations in intake due to intensive sampling. Experimental methodologies and milk production results of this experiment have already been reported in a paper comparing sampling sites for ruminal flow measurements by Fatehi et al. (2015).

This study included 4 dietary treatments, in which crimped barley was replaced with 4 incremental levels of TCM supplementation in grass silage-based diets [none (**B**) and low (**CL**), medium (**CM**), and high (**CH**) dietary canola meal inclusion]. The diets were supplied to the cows according to a Latin square design in 4 experimental periods. The silage was prepared from the primary and regrowth of a second-year sward consisting of timothy (80%; *Phleum pratense*) and red clover (20%; *Trifolium pratense*). The TCM was a commercial solvent-extracted and heat-moisture-treated protein supplement (ExPro-00SF, Aarhus Karlshamn AB, Malmö, Sweden) containing some added fat and minerals. Rations were prepared manually each day, and silage and concentrate were fed separately. The DM concentration of the grass silages and concentrate ingredients was determined twice and once a week, respectively, for adjustment of the dietary forage to a concentrate ratio of 60:40 on DM basis.

Sampling Procedures and Preparation of Digesta and Milk Samples

Each experimental period lasted for 21 d, with the last 10 d used for sample collection. Total DMI was measured between d 12 and 21, and total-tract digestibility of the diets was determined by spot sampling of feces during d 18 to 21. The average results from acid-insoluble ash (Van Keulen and Young, 1977) and indigestible NDF (**iNDF**; Huhtanen et al., 1994) marker methods were used to estimate total-tract digestibility.

Two rumen evacuations were conducted, at d 12 and 14, 4 h after and 1 h before the morning feeding, respectively, to give a representative estimate of the rumen pool size. An arithmetic mean of at least 2 evacuations is recommended when animals are only fed twice daily (Huhtanen et al., 2007). The rumen evacuation technique is based on assumptions of a steady-state rumen pool size and no disturbance of the normal rumen function (Robinson et al., 1987). During the evacuations, particulate and fluid matter were separated, weights