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Effect of substitution of soybean meal by canola meal or distillers grains in dairy rations on amino acid and glucose availability

G. Maxin,[1,2] D. R. Ouellet, and H. Lapierre
Agriculture and Agri-Food Canada, Dairy and Swine Research and Development Centre, Sherbrooke, Québec, Canada J1M 0C8

ABSTRACT

Canola meal (CM) or by-products of ethanol production (dried distillers grain, DDG) may offer an economical alternative to soybean meal (SBM) in North American dairy rations. These protein supplements can effectively replace SBM and, in 2 recent meta-analyses, CM had a positive effect on milk and milk protein yields compared with SBM. The objective of this study was to determine if the positive responses observed with inclusion of CM in dairy rations could be explained by an increased availability of His, Lys, Met, or glucose. Eight Holstein dairy cows were used in a replicated 4 × 4 Latin square with 14-d periods. Cows were fed isonitrogenous (17.2% crude protein) and isoenergetic (1.56 Mcal/kg of net energy of lactation) diets formulated to slightly exceed nutrient requirements. Diets contained 38% grass hay and 62% corn-based concentrate including SBM, CM, corn high-protein DDG (HPDDG), or wheat DDG plus solubles (WDDGS) as the single protein supplement. The effect of protein supplements on availability of His, Lys, Met, and glucose was estimated using variations in the whole-body (WB) flux of these nutrients, determined by isotopic dilution. As planned, dry matter intake and milk and milk protein yields were not affected by treatments and averaged 23.7, 31.4, and 1.14 kg/d, respectively. Lactose yield did not differ among diets although milk lactose content tended to be lower with CM and WDDGS diets than with SBM and HPDDG diets. Lysine availability was affected by treatments: the highest WB irreversible loss rate (ILR) was observed for the CM diet (371 g/d) and the lowest for HPDDG diet (290 g/d); values for SBM and WDDGS were intermediate (330 and 316 g/d, respectively). Availability of His and Met did not vary among diets and WB ILR averaged, respectively, 129 and 124 g/d; the CM diet, however, had numerically the highest His and Met ILR. Plasma concentrations of most of the essential AA were higher with the CM diet and lower with the HPDDG diet, the exception being Leu for which the concentration was highest for the HPDDG diet. Glucose WB rate of appearance was altered by diet, with the highest mean observed for SBM (3,036 g/d) and the lowest for CM (2,795 g/d); the 2 diets with the lowest WB glucose rate of appearance (CM and WDDGS) also had the lowest dietary starch concentration. Overall, this study suggested that positive responses in milk and milk protein yields observed with inclusion of CM in dairy rations could be linked to a greater supply of metabolizable protein, including some essential AA, especially His, Lys, and Met, as glucose availability was certainly not increased in cows fed the CM diet.

Key words: protein supplement, canola meal, amino acid, glucose

INTRODUCTION

Different protein supplements such as canola meal (**CM**) or dried distillers grains (**DDG**) are now widely used in North American dairy rations as an economical alternative to soybean meal (**SBM**). In western Canada, CM is the principal protein supplement included in dairy rations because it is locally available and contains adequate protein concentration and AA profile for dairy cattle nutrition (Hickling, 2008; Newkirk, 2009). With continued expansion of the ethanol industry in North America, DDG is becoming a common feed ingredient in cattle, used to supply both protein and energy (Schingoethe et al., 2009; Zhang et al., 2010). Moreover, changes in the fractionation process to improve the fermentation of corn to ethanol have resulted in new products, such as high-protein DDG, which is closer in nutrient composition (higher in CP and lower in fat) to CM and SBM than conventional DDG (Robinson et al., 2008; Schingoethe et al., 2009). Although corn is the most common grain used in ethanol production, wheat is predominantly used in western Canada. Wheat DDG usually has a composition similar to CM or high-protein DDG (approximately 40% CP and 4% fat; Boila and Ingalls, 1994; Li et al., 2012).

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[1]Corresponding author: gaelle.maxin@clermont.inra.fr
[2]Current address: INRA UMR 1213 Herbivores, Site de Theix, F-63122, Saint-Genès-Champanelle, France.

Over the last few years, several studies have compared lactation performances of dairy cows fed rations including SBM, CM, corn high-protein DDG (**HP-DDG**), or wheat DDG with solubles (**WDDGS**; e.g., Kelzer et al., 2009; Christen et al., 2010; Chibisa et al., 2012). These studies concluded that feeding these protein supplements may be as effective as feeding SBM to lactating dairy cows. Moreover, a recent meta-analysis (Huhtanen et al., 2011) observed that milk and milk protein responses were higher with incremental levels of inclusion of CM in diets compared with inclusion of SBM. Another recent meta-analysis (Martineau et al., 2013) reported positive responses in milk and milk protein yields when CM replaced different protein supplements, the response in milk protein yield being higher in experiments in which CM replaced protein supplements other than SBM, as DDG. These positive responses in milk and milk protein yields with CM might be related to a more efficient N metabolism with improved microbial protein synthesis, a greater supply of MP from the RUP fraction, including some essential AA (especially His, Lys, and Met), or both. Indeed, Lys content in corn DDG is low and might limit milk and milk protein synthesis (Nichols et al., 1998), whereas Met is often the first-limiting AA in SBM-based diets (Illg et al., 1987).

The increase in milk yield is usually paralleled by an increase in lactose secretion because milk yield depends on mammary lactose synthesis through osmotic regulation (Linzell and Peaker, 1971). Indeed, Martineau et al. (2013) reported an increase in milk lactose yield with inclusion of CM in grass or legume forage-based diets. As glucose would be the main precursor for lactose (Bickerstaffe and Annison, 1974), increased milk lactose yield with inclusion of CM in dairy rations may reflect increased whole-body (**WB**) glucose availability.

We hypothesized that the positive responses of milk and milk protein yields to CM substitution were due to increased availability of His, Lys, Met, or glucose. Thus, the objective of this study was to compare the effects of feeding lactating cows with diets containing SBM, CM, HPPDG, or WDDGS as the single protein supplement, on N utilization and WB availability of His, Lys, Met, and glucose.

MATERIALS AND METHODS

Cows and Treatments

Eight rumen-fistulated Holstein cows, averaging 730 ± 43.2 kg of BW and 206 ± 29.4 DIM at the beginning of the study, were used for the experiment. The study was designed as a replicated 4 × 4 Latin square balanced for residual effects, with 14-d experimental periods. The cows were housed in tie-stalls and milked twice daily at 12-h intervals. The experimental protocol was approved by the Institutional Animal Care Committee of the Sherbrooke Dairy and Swine Research and Development Centre and animals were treated according to the Canadian Council on Animal Care (1993) guidelines.

Dietary treatments consisted of inclusion of different protein supplements in the diet: solvent-extracted SBM (Vita Plus, Lake Mills, WI), solvent-extracted CM (Bunge, Harrowby, MB, Canada), HPDDG (Poet's, Albert Lea, MN), and WDDGS (Terra Grain Fuel, Belle Plaine, SK, Canada). The chemical compositions of these protein supplements have been previously reported (Maxin et al., 2013). The 4 diets were formulated to be isonitrogenous at 17.2% CP and isoenergetic at 1.56 Mcal of NE_L/kg of DM (NRC, 2001), with a fixed forage-to-concentrate ratio of 62:38 (DM basis, Table 1). Importantly, all diets were formulated to meet or exceed the nutrient requirements according to NRC (2001), this being a prerequisite for the utilization of the method described below to assess variation in AA availability (Borucki Castro et al., 2008). Cows were individually fed at 95% of ad libitum intake, the latter being determined the week before the initiation of the experiment. To achieve steady-state conditions, the diets were offered in 12 equal meals (at 2-h intervals) using automated feeders (Ankom Technology, Fairport, NY).

Measurements and Sampling

Feed intake was recorded daily. Samples of hay, concentrates, and mixed diets were collected weekly and dried in a forced-air oven at 55°C for 24 h to determine DM content. Then, samples were pooled by period and ground to pass a 1-mm screen before analyses. Milk production was recorded at each milking, and milk samples were collected on the last 6 milkings of each period to analyze milk composition on each sample.

Total urine excretion was collected from d 10 to 13. Urine was collected in stainless steel containers via a Gooch tube (BF Goodrich Co., Kitchener, ON, Canada) attached to the vulva of the cow with nylon netting covered with neoprene (Spall Bowan Ltd., Guelph, ON, Canada). Urine was acidified twice a day with 88 mL/d of concentrated H_2SO_4, and representative daily samples were frozen until analyses.

The availability of His, Lys, and Met was estimated using the variation in the WB irreversible loss rate (**ILR**) of each AA, determined by the isotope dilution technique following a pulse dose of labeled AA. This technique offers a reliable and noninvasive method to estimate changes in the availability of essential AA, as