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Effects of replacing canola meal with solvent-extracted camelina meal on microbial fermentation in a dual-flow continuous culture system

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ABSTRACT

Camelina is an oil seed crop that belongs to the Brassica family (*Cruciferae*). Camelina meal is a by-product from the biofuel industry that contains on average 38% crude protein and between 10 to 20% of residual fat, which limits the inclusion levels of camelina meal in dairy cow diets as the main protein supplement. Thus, we conducted a solvent extraction on ground camelina seed on a laboratory scale. The objectives of this study were (1) to assess the effects of replacing canola meal (CM) with solvent-extracted camelina meal (SCAM) in lactating dairy cow diets; and (2) to determine the effects of SCAM on microbial fermentation and AA flow in a dual-flow continuous culture system. Diets were randomly assigned to 6 fermenters in a replicated 3 × 3 Latin square with three 10-d experimental periods consisting of 7 d for diet adaptation and 3 d for sample collection. Treatments were 0, 50, and 100% SCAM inclusion, replacing CM as the protein supplement. Diets contained 55:45 forage:concentrate, and fermenters were fed 72 g of dry matter/d equally divided in 2 feeding times. On d 8, 9, and 10 of each period, samples were collected for analyses of pH, volatile fatty acids (VFA), N metabolism, NH_3-N, digestibility, and AA flow. Statistical analysis was performed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC), and linear and quadratic effects of SCAM inclusion were assessed. Total VFA concentration and pH were not affected by diets. Molar proportion of acetate decreased, whereas molar proportion of propionate increased with SCAM inclusion. Total branched-chain VFA concentration was the least in fermenters fed diet 0, and greatest in fermenters fed diet 50. Digestibility of NDF decreased in fermenters fed SCAM diets, and dry matter, organic matter, and crude protein true digestibility were similar across diets. Concentration of NH_3-N linearly decreased, and non-NH_3-N linearly increased with SCAM inclusion. Bacterial efficiency (calculated as g of bacterial N flow/kg of organic matter truly digested) tended to be greater in fermenters fed diet 100. Outflow of Arg linearly increased with SCAM inclusion, whereas overall AA flow was not affected by diet. In conclusion, replacing CM with SCAM increased propionate molar proportion and non-NH_3-N flow, and decreased NH_3-N flow and concentration, which may improve animal energy status and N utilization. Inclusion of SCAM did not change most AA flow, indicating that it can be a potential replacement for CM.
Key words: amino acid, digestibility, nitrogen metabolism

INTRODUCTION

Camelina sativa is also referred as false flax for its similarity to flax seed regarding the relatively high proportion of n-3 fatty acids (Fröhlich and Rice, 2005). It is a drought- and salt-tolerant oil seed crop from the Brassica (*Cruciferae*) family. Camelina meal (**CAM**) is the by-product from biofuel industry, which is currently obtained in an industrial scale via mechanical pressing using an expeller (Fröhlich and Rice, 2005; Ye et al., 2016). Camelina meal contains on average 38% CP (Hixson and Parrish, 2014) and 10 to 20% residual fat (Pekel et al., 2009, 2015; Kahindi et al., 2014).

The demand for renewable alternative sources of biofuel has increased, leading to an intensification in camelina growing areas (Moser and Vaughn, 2010). Extracting oil more efficiently will make this crop more competitive and will enable greater meal inclusion in ruminant diets. Aside from its high residual fat, CAM use in ruminant diets as the sole protein supplement is limited by the concentration of anti-nutritional factors, primarily glucosinolates (Berhow et al., 2013), which are associated with deleterious effects notably in the thyroid gland (Holst and Williamson, 2004).

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Camelina belongs to the same family as canola and their meals have similar protein concentration and AA composition (Colombini et al., 2014). Canola meal (**CM**) is widely used in North America as a protein supplement for dairy cows, and it has been associated with increased milk production, DMI (Martineau et al., 2013), and decreased MUN (Paula et al., 2018). Therefore, having an alternative protein supplement with similar fermentation profile and nutrient flow as CM would represent a beneficial opportunity to the dairy industry.

Recently our research group demonstrated that isonitrogenous (16% CP) diets containing camelina seed plus CM, had similar N metabolism when fed at 5% ether extract (**EE**) compared with diets containing only CM as a protein supplement (Brandao et al., 2018). However, the great EE concentration (35%) in camelina seed limited its inclusion in the diets. To overcome this and enable a partial and complete replacement of CM by CAM, we performed a solvent fat extraction on ground camelina seed on a laboratory scale, yielding solvent-extracted CAM (**SCAM**). We hypothesized that SCAM could partially or completely replace CM as a protein supplement in lactating dairy cow diets without negatively affecting microbial fermentation. The objectives were (1) to assess the effects of replacing CM with SCAM in lactating dairy cow diets, and (2) to determine the effects of SCAM on microbial fermentation and AA flow in a dual-flow continuous culture system. To our knowledge, this was the first time that data on microbial fermentation and AA flow of SCAM were reported.

MATERIALS AND METHODS

The University of Nevada, Reno, Institutional Animal Care and Use Committee approved the animal care and handling protocol used in this experiment (protocol # 00588).

Experimental Design and Diets

This study was conducted in a replicated 3 × 3 Latin square with three 10-d experimental periods consisting of 7 d for diet adaptation and 3 d for sample collection. Each fermenter unit was randomly assigned to receive each diet once over the 3 experimental periods, in which a treatment did not follow the same treatment more than once. Fermenters were manually fed 72 g/d (DM basis) equally distributed twice daily at 0800 and 1800 h. Treatments were (1) 0% SCAM (0), (2) 50% SCAM (50), and (3) 100% SCAM (100) inclusion, replacing CM as the protein supplement.

Table 1. Ingredient and chemical composition of the experimental diets (% DM, unless otherwise stated)

	Treatment[1]		
Item	0	50	100
Ingredient composition			
Orchard grass hay	55.0	55.0	55.0
Ground corn	22.3	23.0	23.6
Solvent-extracted canola meal	20.6	10.3	—
Solvent-extracted camelina meal	—	10.1	20.2
Camelina oil	0.82	0.41	—
Mineral mix[2]	1.26	1.25	1.24
Chemical composition			
DM, %	87.0	86.9	86.8
OM	92.3	92.1	92.0
CP	16.0	16.0	16.0
NDF	41.8	40.6	39.4
ADF	20.4	20.3	20.3
Ether extract	3.42	3.41	3.40
NFC[3]	32.3	33.4	34.4
NE_L,[4] Mcal/kg of DM	1.50	1.51	1.51
Glucosinolates, mg/g	0.30	1.36	2.41

[1]0 = no solvent-extracted camelina meal inclusion; 50 = 50% of solvent-extracted camelina meal inclusion; 100 = 100% of solvent-extracted camelina meal inclusion replacing canola meal as a protein supplement.

[2]Provided (per kg of DM): 955 g of NaCl, 3,500 mg of Zn, 2,000 mg of Fe, 1,800 mg of Mn, 280 mg of Cu, 100 mg of I, and 60 mg of Co.

[3]Estimated according to NRC (2001), using the following equation: NFC = 100 – (% NDF + % CP + % fat + % ash).

[4]NE_L estimated using the NRC (2001) model.

Experimental diets were formulated to meet or exceed NRC recommendations (NRC, 2001) for a 660-kg Holstein dairy cow producing 35 kg of milk/d consisting of 3.5% fat and 3.2% protein. Diets contained (DM basis) 55% orchardgrass hay and 45% concentrate, and were formulated to be isonitrogenous (16% CP) and to have approximately 3.4% of EE (Table 1). Dietary ingredients consisted of orchardgrass hay, ground corn, and either solvent-extracted CM or CAM as protein supplement.

Before oil extraction, camelina seed (genotype Calena) used in this experiment contained 35.5% EE and 29.4% CP (DM basis). Fat extraction was performed at the Applied Research Facility, located in the Department of Natural Resources and Environmental Science (University of Nevada, Reno), assisted by Glenn Miller. Fat extraction was performed using hexane (Sigma-Aldrich Co., St. Louis, MO) as solvent at rate of 6.4 mL of hexane/g of ground seed, using a refluxing solvent extractor. Temperature and pressure were controlled during the entire extraction process, which yielded a meal containing 6.1% EE and 39% CP (DM basis, Table 2). Canola meal used in this experiment was produced industrially by solvent extraction. To have similar EE across diets and isolate possible confounding effects of EE source, camelina oil was added to diets 0 and 50