J. Dairy Sci. 96:2551–2556
http://dx.doi.org/10.3168/jds.2012-6426

Short communication: Effect of oilseed supplementation of an herbage diet on ruminal fermentation in continuous culture

K. J. Soder,*[1] A. F. Brito,† and M. D. Rubano*
*USDA-Agricultural Research Service, Pasture Systems and Watershed Management Research Unit, University Park, PA 16802
†Department of Biological Sciences, University of New Hampshire, Durham 03824

ABSTRACT

A 4-unit continuous culture fermentor system was used to evaluate the effects of oilseed supplementation of an herbage-based diet on nutrient digestibility, fermentation profile, and bacterial nitrogen (N) synthesis. Treatments were randomly assigned to fermentors in a 4 × 4 Latin square design with 7 d for diet adaptation and 3 d for data and sample collection. Dietary treatments were an herbage-only diet (HERB), or the following ground oilseeds supplemented to an herbage-based diet at 10% of total dry matter (DM) fed: flaxseed (FLAX), canola (CAN), or sunflower (SUN). Apparent DM, organic matter, and neutral detergent fiber digestibility were not affected by diet, averaging 62, 68, and 78%, respectively. True DM and organic matter digestibility were not affected by diet, averaging 78 and 82%, respectively. Fermentor pH and total volatile fatty acids were not affected by diet. Branched-chain volatile fatty acids tended to be lower for HERB compared with the 3 oilseed diets. Ammonia N concentrations were lowest for the HERB diet. Crude protein digestibility was not affected by diet. Flow of NH_3-N was lowest for the HERB diet reflecting the lowest culture concentration of NH_3-N. Bacterial N flows were lowest for HERB and SUN diets, intermediate for FLAX, and greatest for CAN. Flows of total N, non-NH_3-N, and dietary N were not affected by diet. Likewise, efficiency of bacterial N synthesis was not affected by diet. Supplementation with FLAX, CAN, or SUN at 10% of total DM fed did not affect nutrient digestibility or ruminal fermentation compared with an all-herbage diet. The oilseeds tested herein may be considered as alternative energy supplements for grazing dairy cows, particularly during times of low availability of corn. However, in vivo studies are needed to further evaluate the effects of oilseeds supplementation of an herbage-based diet on milk production and composition (specifically human-beneficial fatty acids).

Key words: herbage, in vitro fermentation, oilseed

Short Communication

Oilseeds have been used as a supplemental source of fat in dairy rations in an attempt to improve energy supply while modifying milk FA profile. For instance, the milk concentration of functional lipids such as conjugated linoleic acids (**CLA**; Glasser et al., 2008) and n-3 FA (Larsen et al., 2012) generally increases when feeding oilseeds, particularly flaxseed (*Linum usitatissimum*). Recent literature reviews (McCrorie et al., 2011; Dilzer and Park, 2012) have documented a variety of potential health benefits to humans attributed mostly to the *cis*-9,*trans*-11 and *trans*-10,*cis*-12 isomers of CLA, such as reduced body fat, cardiovascular diseases, and cancer, as well as modulation of immune and inflammatory responses. Likewise, it is now recognized that n-3 FA are essential for normal growth, brain development, vision, and immunity in infants, and have been linked to prevention and treatment of cardiovascular diseases (Williams, 2000). It is important to note, however, that further research, specifically clinical studies with defined subject characteristics, experimental durations, and FA doses, is needed to elucidate the role of these functional lipids (e.g., CLA and n-3 FA) on preventing chronic diseases in humans (McCrorie et al., 2011; Dilzer and Park, 2012).

Because of current high prices and reduced availability of corn combined with the potential health benefits attributed to CLA and n-3 FA, interest is growing in feeding oilseeds as the sole energy supplement source on grazing dairy farms. Both milk FA profile and ruminal fermentation responses to oilseeds may vary based on the composition of the basal diet (Chilliard et al., 2007; Glasser et al., 2008), level and type of oilseed supplementation (Glasser et al., 2008; Beauchemin et al., 2009; Soder et al., 2012), and method of oilseed processing (Gonthier et al., 2004, 2005; da Silva et al., 2007; Martin et al., 2008). However, most of this previous research was conducted with confined dairy cows fed conserved forages incorporated into TMR diets. Furthermore, direct comparisons of various oilseeds on ruminal fermentation and bacterial protein synthesis are limited, particularly when supplemented to an herbage-based diet. Therefore, the objective of this

Received November 27, 2012.
Accepted December 8, 2012.
[1]Corresponding author: kathy.soder@ars.usda.gov

study was to evaluate the effects of replacing orchardgrass (*Dactylis glomerata* L.) herbage (**HERB**) with 3 different oilseeds (flaxseed, **FLAX**; canola seed, **CAN**; or sunflower seed, **SUN**) on ruminal fermentation, apparent nutrient digestibility, and nitrogen (N) metabolism during continuous culture fermentation. We hypothesize that replacing herbage with oilseeds will change culture fermentation profile due to enhanced supply of dietary unsaturated FA, which can affect nutrient digestibility and bacterial protein synthesis.

This study was conducted at the USDA-ARS Pasture Systems and Watershed Management Research Unit (University Park, PA), from January to April 2011. Each fermentor was fed a total of 70 g of DM/d of 1 of 4 diets: 100% HERB, or orchardgrass herbage plus 1 of 3 oilseeds (FLAX, CAN, or SUN) supplemented at a rate of 10% of total DM fed. Oilseeds and herbage were ground to pass through a 2-mm screen. Each fermentor received herbage in 4 equal feedings at 0730, 1030, 1400 and 1900 h. The oilseed treatments were fed twice daily in equal amounts at 0730 and 1400 h. The study was a 4 × 4 Latin square design with each dual-flow continuous culture fermentation unit receiving each treatment once over the 4 periods. The continuous culture fermentor system, sample collection, and analyses were conducted per the methods of Soder et al. (2012). Herbage, oilseeds, and effluent were analyzed by wet chemistry (DairyOne Laboratories, Ithaca, NY) according to the following methods: DM (method 930.15; AOAC International, 2006), CP (method 990.03; AOAC International, 2006), NDF (Van Soest et al., 1991), water-soluble carbohydrates, ethanol-soluble carbohydrates (Hall et al., 1999), starch (Application Note Number 319; YSI Inc. Life Sciences, Yellow Springs, Ohio), and ether extract (method 2003.06; AOAC, 2006). The RDP was determined using the procedures of Coblentz et al. (1999). The concentration of NSC was calculated by adding water-soluble carbohydrates plus starch. Concentrations of total purines (Zinn and Owens, 1986) in effluent and bacterial isolates were used to partition effluent N flow into bacterial and non-bacterial fractions and to calculate true DM and OM digestibilities and flows.

Data were analyzed as a 4 × 4 Latin square design using the GLM procedure of SAS (SAS Institute Inc., Cary, NC). The model included the fixed effects of treatment and period, the random effect of fermentor, and the residual error. Least squares means and SEM are reported for all data. Significance was declared at $P < 0.05$ and trends between $P > 0.05$ and $P < 0.10$. Apparent nutrient digestibility and nutrient flows were calculated per the equations used in Soder et al. (2012).

Nutrient compositions of the herbage, supplements, and the experimental diets are presented in Table 1. The use of pooled samples for compositional analysis precluded statistical comparison of treatments. The level of fat in all diets was within NRC (2001) recommendations for dairy diets, that is, an upper limit of 3 to 4% added fat and 6 to 7% of total fat in the dietary DM. In general, the nutrient composition of all 4 experimental diets was very similar due to the low dietary inclusion (10% of the diet DM) of oilseeds despite some differences in nutrient profile of the individual oilseeds.

Apparent digestibilities of DM, OM, and NDF were not affected by diet, averaging 62, 68, and 78%, respectively (Table 2). Likewise, true DM and OM digestibilities were not affected by replacing herbage with oilseeds, averaging 78 and 82%, respectively (Table 2). The current results agree with those of Gonthier et al. (2004), who showed in lactating dairy cows no effect of different forms (i.e., raw, micronized, or extruded) of flaxseed (supplemented at 12.6% of diet DM) on ruminal digestibilities of DM, OM, NDF, CP, FA, and gross energy compared with the control (no supple-

Table 1. Chemical composition (% of DM) of a 100% herbage diet (HERB) or an herbage diet supplemented with either 10% flaxseed (FLAX), canola (CAN), or sunflower seed (SUN) during continuous culture fermentation

	Ingredient			Diet[1]			
Item	Flaxseed	Canola	Sunflower	HERB	FLAX	CAN	SUN
OM	89.7	91.7	93.9	93.6	93.2	93.4	93.6
CP	21.4	24.7	23.3	22.1	22.0	22.4	22.2
RDP, % of CP	69.0	65.0	68.0	74.0	73.5	73.1	73.4
NDF	23.1	31.7	38.1	54.2	51.1	52.0	52.6
WSC[2]	4.2	8.0	4.8	10.9	10.2	10.6	10.3
ESC[2]	3.5	7.4	4.5	9.3	8.7	9.1	8.8
Starch	0.5	0.3	0.1	1.7	1.6	1.6	1.5
NSC	4.7	8.3	4.9	12.6	11.8	12.2	11.8
Ether extract	20.7	37.5	41.8	3.5	5.2	6.9	7.3

[1]Calculated using actual nutrient composition and proportion of individual ingredients.

[2]WSC = water soluble carbohydrate; ESC = ethanol soluble carbohydrate.