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Ruminal degradation and intestinal digestibility of camelina meal and carinata meal compared with other protein sources

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ABSTRACT

Production of reneweable feedstocks for biodiesel have drawn attention to alternative oilseed crops. Our objective was to determine DM and CP ruminal degradability and intestinal digestibility of camelina meal (CAM) and carinata meal (CAR), compared with canola meal (CAN), linseed meal (LIN), soybean meal (SBM), and distillers dried grains with solubles (DDGS) as controls. In situ degradability measurements were done using 3 multiparous, mid-late lactation ruminally cannulated Holstein cows. Sample bags were ruminally incubated in duplicate for each cow and feedstuff for 0, 2, 4, 8, and 12 h and in triplicate for 24 and 48 h. Eight bags of each feed were incubated at 12 h for use of the residues in determination of in vitro intestinal digestibility. Ruminal particulate passage rate averaged 6.0%/h. Rate of DM degradation was greatest ($P < 0.05$) for CAM and LIN and least for DDGS, whereas CAR and SBM were similar. Ruminally degradable DM was greatest ($P < 0.01$) in CAM, CAR, and SBM. The CAM and CAR had the greatest ($P < 0.05$) RDP and least RUP. Intestinal digestible protein was similar ($P > 0.05$) for LIN, CAM, and CAR, which was greater ($P < 0.05$) than CAN and DDGS. Intestinally absorbable digestible protein was least for CAM and CAR ($P < 0.01$) compared with the other feeds. Total digestible protein was similar ($P > 0.05$) for CAM and CAR compared with SBM and LIN. Results indicate that CAM and CAR are highly degradable and comparable to SBM and LIN for protein utilization.

Key words: camelina meal, carinata meal, digestibility, ruminal degradability

INTRODUCTION

Finding alternative feedstocks for the production of biodiesel has been increasing in interest over many years (Cardone et al., 2003; Frohlich and Rice, 2005). Currently, the feedstocks used for biodiesel production include canola, soybean, palm, and sunflower oil (Moser, 2010). To continue to find new fat sources for biodiesel it is imperative to find other renewable sources of biofuel feedstocks (Milazzo et al., 2013). Due to this demand, *Brassica* crops *B. carinata* and *Camelina sativa* are being introduced to South Dakota, Minnesota, North Dakota, and Montana (American Society of Agronomy, 2015; Atyeo, 2015). The oilseed *B. carinata* is also known as Ethiopian mustard or carinata; it is able to adapt to adverse soil conditions and semi-arid conditions (Cardone et al., 2003). The oil content of carinata seed is mostly very-long-chain fatty acids or erucic acid (C22:1; Cardone et al., 2003). The by-product left after extraction of the oil is carinata meal (**CAR**), and it could potentially be a protein source for livestock (Marillia et al., 2014). The oilseed *C. sativa* is comparative to carinata in agronomic benefits and is also being introduced in the Midwest. It is commonly known as false flax or camelina, and the total oil content of the seeds is similar to that of carinata seeds; however, camelina oil contains more n-3 and n-6 fatty acids and less erucic acid (Putnam et al., 1993; Zubr, 1997; Waraich et al., 2013). The main concern with feeding camelina meal (**CAM**) and CAR is the antinutritional compounds found in all *Brassica* species (Tripathi and Mishra, 2007). When feeding CAM and CAR, the effects of glucosinolates on thyroid function pose a problem (Fales et al., 1987). Ruminants are more tolerant of glucosinolates; however, it is not recommended to feed meals containing glucosinolates in excess of 10% inclusion in the diet, which is currently the federal regulation (AAFCO, 2014). Therefore, we want to characterize the glucosinolate content found in these novel feeds. The CAM and CAR by-products are relatively new to the United States and not yet widely used in dairy cattle diets. Thus, it was important to determine how the meals are used by dairy cattle as sources of protein and how they compare with other common protein sources. This was a preliminary study, and the main objective was to determine, at an initial level, the DM and CP ruminal degradability and intestinal digestibility of CAM and CAR directly compared with canola meal (**CAN**), linseed meal (**LIN**), soybean meal (**SBM**), and distillers dried grains with solubles (**DDGS**). The purpose of comparing them to these feeds was to gain insight on which feeds CAM and CAR could best be substituted for or compete with in dairy cattle diets. It was hypothesized that CAM and CAR are more ruminally degradable than CAN

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and DDGS, but it was unknown how they would compare with SBM and LIN.

MATERIALS AND METHODS

Animal Care

All animal procedures and uses were approved by the South Dakota State University Institutional Animal Care and Use Committee. The specific project approval number for this study was 14–026A. The institutional Animal Welfare Assurance number filed with the Health Service Office for Protection from Research Risks was #A3958–01.

In situ measurements were conducted using 3 multiparous mid-late lactation ruminally cannulated Holstein cows during summer 2014. During the trial cows averaged 848.6 ± 94.7 kg of BW, 229.7 ± 91.1 DIM, and 22.7 ± 2.0 kg/d of milk yield. Cows were milked 3 times per day at 0600, 1400, and 2100 h. During the study, cows were housed in individual box stalls bedded with straw with ad libitum access to water. Cows were fed the same TMR as was fed to the main lactating herd at the Dairy Reseach and Training Facility at the time of the study (Table 1). Feed was offered daily at 0730 h and fed using individual feed boxes placed inside the stall. Individual feed intakes were measured daily, and intakes were used to calculate passage rate. Average DMI for the 3 cows during the study was 24.7 ± 2.4 kg/d. Diets were fed on an ad libitum basis as a TMR with a forage-to-concentrate ratio of 53:47. Feed samples were taken of the TMR offered each day and frozen (−20°C) until later analysis.

In Situ Procedures

Six feeds were analyzed: CAM, CAR, CAN, DDGS, LIN, and SBM. At the time of the study CAM and CAR were not widely commercially available in South Dakota. A 1.36-t test batch of the CAM was obtained from Sustainable Oils (Seattle, WA), which was later used for a heifer feeding study (Lawrence et al., 2016). A small test sample of the CAR was obtained from Agrisoma Inc. (Saskatoon, Canada). The other test feeds were found locally: DDGS was from the Dakota Ethanol Plant (Wentworth, SD), SBM was from South Dakota Soybean Processors (Volga, SD), LIN was from the Archer Daniels Midland Company (ADM, Redwing, MN), and CAN was also from ADM (Enderlin, ND). Cold press extraction was the method of processing for CAM. Although similar to mechanical expeller extraction, cold press extraction has the added requirement that temperature during extraction is limited to less than 49°C (Schaufler and Schaufler, 2017). Carinata meal, LIN, CAN, DDGS, and SBM were processed using solvent extraction methods. Solvent extraction using hexane is very efficient, and the resulting meal contains less oil than extraction using a press (Goss, 1947).

Five grams of each feed was weighed into 10 × 20 cm Dacron bags with a pore size of 50 μm (Ankom Technology, Macedon, NY) and heat sealed using an impulse sealer. Bags were prepared for each cow and feedstuff in duplicate for the 0-, 2-, 4-, and 8-h incubation periods. Eight bags were prepared for the 12-h incubation period

Table 1. Ingredient and nutrient composition of the TMR fed to lactating cows during the in situ experiment

Item	Value
Ingredients, % of DM	
Corn silage	34.70
Alfalfa haylage	7.00
Alfalfa hay	8.30
Alfalfa pellets	2.96
High-moisture corn	14.53
Whole cottonseed	5.25
Distillers dried grains with solubles	5.50
Soy hulls	1.34
Dairy sugar[1]	3.79
Soybean meal, 44% CP	6.90
Ground corn	3.15
Bypass soybean meal[2]	2.22
Vitamin, mineral, and supplements[3]	4.41
Nutrient composition,[4] % of DM unless otherwise noted	
DM	50.75
CP	17.04
RDP	9.84
RUP	7.19
ADF	19.71
NDF	29.41
NFC[5]	40.70
Starch	25.13
Ether extract	5.30
NE_l,[6] Mcal/kg	1.72

[1]QLF Dairy sugar (Quality Liquid Feeds, Dodgeville, WI). Liquid mixture of cane molasses, condensed whey, and tallow.

[2]Soybest Pearl (Kemin, West Point, NE).

[3]Vitamin, mineral, and supplement mix: 0.93% limestone, 0.83% sodium bicarbonate, 0.37% salt, 0.65% bypass fat (Energy Booster, Milk Specialties, Eden Prairie, MN), 0.62% blood meal (swine), 0.2% urea (46% CP), 0.2% Diamond V XP Yeast (Diamond V Mills Inc., Cedar Rapids, IA), 0.16% trace mineral supplement (Avail4, Zinpro International Nutrition, Omaha, NE), 0.19% magnesium oxide, 0.10% calcium phosphate (21%), 0.09% immune health supplement (Omnigen, Prince Agri Products, Teaneck, NJ), 0.03% vitamin E 44,000 IU/kg, 0.01% Rumensin (198 g/kg, Elanco Animal Health, Greenfield, IN), and 0.01% biotin (1%, 9,979.2 mg/kg).

[4]Laboratory analysis was performed at Dairyland Laboratories Inc. (Arcadia, WI).

[5]% NFC (nonfibrous carbohydrates) = 100 − (% ash + % CP + % NDF + % ether extract) (NRC, 2001).

[6]Values are calculated based on inputting sample nutrient analysis into diet formulations in the Dairy NRC computer program (2001).

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