J. Dairy Sci. 97:1543–1551
http://dx.doi.org/10.3168/jds.2013-6728

Effect of feeding extruded flaxseed with different grains on the performance of dairy cows and milk fatty acid profile

C. Neveu,* B. Baurhoo,†[1] and A. Mustafa*[1]
*Department of Animal Science, McGill University, Ste-Anne-De-Bellevue, QC, H9X 3V9, Canada
†Belisle Solution and Nutrition Inc., Saint-Mathias sur Richelieu, QC, J3L 6A7, Canada

ABSTRACT

Sixteen Holsteins cows were used in a Latin square design experiment to determine the effects of extruded flaxseed (EF) supplementation and grain source (i.e., corn vs. barley) on performance of dairy cows. Extruded flaxseed diets contained 10% [dry matter (DM) basis] of an EF product that consisted of 75% flaxseed and 25% ground alfalfa meal. Four lactating Holsteins cows fitted with rumen fistulas were used to determine the effects of dietary treatments on ruminal fermentation. Intakes of DM (23.2 vs. 22.2 kg/d), crude protein (4.2 vs. 4.0 kg/d), and neutral detergent fiber (8.3 vs. 7.9 kg/d) were greater for cows fed EF diets than for cows fed diets without EF. Milk yield and composition were not affected by dietary treatments. However, 4% fat-corrected milk (30.5% vs. 29.6 kg/d) and solids-corrected milk (30.7 vs. 29.9 kg/d) were increased by EF supplementation. Ruminal pH and total volatile fatty acid concentration were not influenced by EF supplementation. However, feeding barley relative to corn increased molar proportions of acetate and butyrate and decreased that of propionate. Ruminal NH_3-N was lower for cows fed barley than for cows fed corn. Milk fatty acid composition was altered by both grain source and EF supplementation. Cows fed EF produced milk with higher polyunsaturated and lower saturated fatty acid concentrations than cows fed diets without EF. Feeding EF or corn increased the milk concentration of C18:0, whereas that of C16:0 was decreased by EF supplementation only. Extruded flaxseed supplementation increased milk fat α-linolenic acid content by 60% and conjugated linoleic acid content by 29%. Feeding corn relative to barley increased milk conjugated linoleic acid by 29% but had no effect on milk α-linolenic concentration. Differences in animal performance and milk fatty acid composition were mainly due to EF supplementation, whereas differences in ruminal fermentation were mostly due to grain source.

Key words: flaxseed, milk composition, fatty acids, corn and barley

INTRODUCTION

Flaxseed is a rich source of both protein and fat. On average it contains 40% oil, 20% CP, and 30% NDF (Petit, 2010). Flaxseed has been fed to lactating dairy cows in various forms such as whole or ground (Caroprese et al., 2010), extruded (Gonthier et al., 2005), and micronized (Mustafa et al., 2003). Feeding different forms of flaxseed to dairy cows increases the concentration of unsaturated fatty acids and decreases the concentration of SFA, particularly C16:0, in milk (Neveu et al., 2013). However, minimal effects on the concentrations of C18:1 and C18:2 have been reported as a result of flaxseed supplementation (Mustafa et al., 2003; Gonthier et al., 2005; Loor et al., 2005a). This is likely due to the ruminal biohydrogenation of flaxseed PUFA. Altering the physical structure (e.g., heat treatment) of flaxseed may help to protect dietary oilseed FA from ruminal biohydrogenation. Application of heat treatments, such as extrusion, to oilseeds can denature the protein matrix surrounding the fat droplet and therefore protect FA from ruminal biohydrogenation (Kennelly, 1996; Gonthier et al., 2005). A major disadvantage of feeding vegetable oils and oilseeds to dairy cows is the significant reduction in milk fat concentration and yield mainly due to the formation of several *trans* and conjugated FA isomers during ruminal biohydrogenation, which negatively affects de novo milk FA synthesis (Loor et al., 2005b; Chilliard et al., 2007; Glasser et al., 2008). Several dietary factors may influence ruminal pH and the microbial population and therefore alter the extent and rate of ruminal biohydrogenation of dietary FA. These include type and concentration of supplementary fat, forage:concentrate ratio, forage type, and composition of basal diet. Modification of ruminal FA biohydrogenation may alter duodenal flow of FA and consequently milk FA composition (Gonthier et al., 2004, 2005; Loor et al., 2004, 2005a).

Received February 22, 2013.
Accepted November 24, 2013.
[1]Corresponding authors: bbaurhoo@belisle.net and arif.mustafa@mcgill.ca

Type and concentration of fermentable carbohydrates can have a major effect on ruminal pH and therefore the rate and extent of ruminal biohydrogenation of dietary PUFA. Sources of fermentable carbohydrates such as grains may vary in their rate of starch fermentation and therefore on their effects on ruminal fermentation parameters such as pH and VFA (Kiran and Mutsvangwa, 2007). Mutsvangwa et al. (2012) showed that changing the availability of ruminally fermentable carbohydrate (through barley processing) and the source of supplemental fat altered duodenal FA flows and milk FA composition. However, no studies have evaluated the interaction between grain source (corn vs. barley) and extruded flaxseed (**EF**) on the performance of lactating dairy cows and milk FA composition.

MATERIALS AND METHODS

Animals and Experimental Design

Experimental procedures were approved by the Animal Care Committee of the Faculty of Agricultural and Environmental Sciences of McGill University. Sixteen lactating Holstein cows (93.1 ± 49.9 DIM) of different parities (10 multiparous and 6 primiparous) were used in a 4 × 4 Latin square experiment with 21-d periods (14 d of adaptation and 7 d of data collection). Dietary treatments were allotted randomly to cows within each block (i.e., DIM). Cows were housed in tiestalls, had free access to water, and were milked twice daily at 0530 and 1700 h.

Dietary Treatments and Sample Collection

Four diets were formulated to meet the nutrient requirements of lactating dairy cows in early lactation (NRC, 2001; Table 1). Dietary treatments were a corn-based diet with no EF, a corn-based diet with EF, a barley-based diet with no EF, and a barley-based diet with EF. The EF product (OmegaPlus, Belisle Solution Nutrition Inc., Saint Mathias, QC, Canada) consisted of 75% flaxseed and 25% ground alfalfa meal (Table 2). The extrusion was carried out using an Insta-Pro extruder (model 2000RC; Insta-Pro International, Des Moines, IA) fitted with an 8100RC volumetric feeder. Extrusion temperature was maintained at 112°C.

Diets were fed as TMR once daily at 0800 h for ad libitum intake. Feed offered and weigh-backs (10% orts as fed) for each cow were measured daily during data collection periods to determine daily feed intake. Diets

Table 1. Ingredients and chemical composition of dietary treatments (DM basis)

	Corn		Barley	
Item	No flaxseed	Flaxseed	No flaxseed	Flaxseed
Ingredients, %				
Corn silage	25.7	25.9	27.3	27.1
Alfalfa haylage	25.8	25.9	27.3	27.1
Grass hay	7.8	7.9	8.3	8.2
High moisture corn	25.6	19.1		
Rolled barley			24.0	17.44
Extruded flaxseed		10.0		10.0
Soybean meal	11.8	7.9	9.6	6.2
Mineral mix[1]	3.3	3.4	3.4	3.4
DM, %	46.8 ± 1.9	48.1 ± 2.5	48.5 ± 1.5	48.7 ± 2.2
Chemical composition, % of DM				
Ash	7.0 ± 0.5	7.3 ± 0.4	7.3 ± 0.4	6.7 ± 0.9
Ether extract	2.3 ± 0.2	2.7 ± 0.3	1.7 ± 0.2	2.3 ± 0.2
NDF	34.4 ± 2.0	35.1 ± 3.9	36.5 ± 1.2	36.2 ± 2.2
ADF	24.3 ± 2.3	25.8 ± 2.7	23.9 ± 0.7	24.9 ± 1.3
ADL	3.4 ± 0.5	3.9 ± 0.6	3.8 ± 0.4	4.1 ± 0.8
CP	17.6 ± 1.7	17.8 ± 1.0	18.0 ± 1.5	18.6 ± 0.9
Neutral detergent insoluble protein	2.5 ± 0.4	2.6 ± 0.4	2.9 ± 0.6	3.0 ± 0.6
Acid detergent insoluble protein	0.9 ± 0.1	0.9 ± 0.2	0.9 ± 0.1	1.0 ± 0.2
Starch	19.3 ± 1.2	16.5 ± 1.5	18.1 ± 0.6	17.4 ± 1.4
NE_L,[2] Mcal/kg	1.62	1.60	1.56	1.59
FA, % of total FA				
C16:0	17.5 ± 1.19	16.1 ± 1.32	19.5 ± 0.47	16.6 ± 1.08
C18:0	2.1 ± 0.12	2.4 ± 0.25	2.0 ± 0.03	2.2 ± 0.08
C18:1	13.0 ± 0.40	13.4 ± 0.31	9.6 ± 0.93	11.6 ± 0.92
C18:2	37.6 ± 2.67	31.8 ± 2.48	36.2 ± 1.14	32.3 ± 0.50
C18:3	18.0 ± 1.06	25.8 ± 1.18	19.9 ± 0.67	27.0 ± 1.82

[1]Contained 16.14% Ca, 2.85% P, 5.12% Mg, 0.48% K, 12.31% Na, 7.57 mg/kg Se.

[2]Calculated using the equation of Weiss et al. (1992).