The Professional Animal Scientist 34:435–446
https://doi.org/10.15232/pas.2018-01726

Evaluation of whole flaxseed and the use of tannin-containing fava beans as an alternative to peas in a co-extruded flaxseed product on ruminal fermentation, selected milk fatty acids, and production in dairy cows

J. Moats,*† T. Mutsvangwa,* B. Refat,* and D. A. Christensen*[1]
*Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK, Canada, S7N 5A8; and †O&T Farms Ltd., Regina, SK, Canada, S4R 8R7

ABSTRACT

This study evaluated the effects of whole versus extruded flaxseed and the use of tannin-containing fava beans as a replacement for peas in an extruded flaxseed-based supplement on rumen fermentation, selected milk fatty acids, and production in dairy cows. Eight Holstein cows were used in a replicated 4 × 4 Latin square consisting of 28-d periods. Cows were fed a control diet (CONT) or 1 of 3 diets that contained a whole flaxseed supplement (FLX), an extruded flaxseed and pea supplement (EXT; linPRO-R, O&T Farms Ltd., Regina, SK, Canada), or an extruded flaxseed and tannin-containing fava bean supplement (EXTT). Dry matter intake was less in cows fed FLX, EXT, and EXTT compared with those fed CONT ($P = 0.006$). Milk yield was greater in cows fed EXT (44.4 kg/d) compared with those fed FLX (42.3 kg/d; $P = 0.023$) and tended to be greater in cows fed FLX, EXT, and EXTT (average 43.5 kg/d) compared with those fed CONT (41.9 kg/d; $P = 0.073$). Milk fat percentage was less in cows fed FLX, EXT, and EXTT compared with those fed CONT ($P = 0.033$); however, milk fat yield was unaffected. The C18:3n-3 and *cis*-9, *trans*-11 conjugated linoleic acid fatty acids were greater in milk of cows fed EXT compared with those fed FLX ($P = 0.001$). No differences in milk fatty acid composition were observed between EXT and EXTT. These results demonstrate that feeding extruded flaxseed supplements containing peas or tannin-containing fava beans effectively improve milk yield and milk fatty acid profile when compared with whole flaxseed.

Key words: dairy cow, flaxseed, extrusion, milk fatty acids, tannin-containing fava beans

INTRODUCTION

Increasing the concentration of total n-3 fatty acids (**FA**), α-linolenic acids (C18:3n-3), and *cis*-9, *trans*-11 conjugated linoleic acid (**CLA**) in bovine milk may benefit consumer health (Lee et al., 2005; Gerber, 2012). Supplementing dairy cow diets with flaxseed products has been suggested as a strategy for improving the concentration of these FA in the milk of dairy cows (Glasser et al., 2008; Petit, 2010; Sterk et al., 2012; Neveu et al., 2013). However, the high concentration of C18:3n-3 in flaxseed (55 g/100 g of total FA; Petit, 2010) has the potential to disrupt ruminal fermentation and cause milk fat depression (NRC, 2001). Additionally, biohydrogenation of C18:3n-3 by rumen microbial processes limits transfer efficiency of C18:3n-3 into the milk (Sterk et al., 2012). Therefore, protecting the C18:3n-3 from the rumen environment is important for successful application of flaxseed-based feeding programs.

Whole flaxseed has been shown to protect the C18:3n-3 from biohydrogenation (Oba et al., 2009); however, total-tract digestibility of whole oilseeds is poor and limits incorporation of C18:3n-3 into the milk (Petit et al., 2005; Martin et al., 2008). Extrusion of flaxseed has been shown to provide partial protection of C18:3n-3 from biohydrogenation (Kennelly, 1996; Sterk et al., 2012). O&T Farms Ltd. (Regina, SK, Canada) manufactures an extruded flaxseed-based feed ingredient (linPRO-R) that contains peas, as an oil-absorbent material. In Canada, a 350% increase in fava bean production between 2013 and 2016 has been reported, with further increases expected (Feyertag, 2017). Increased availability of this crop provides a potential alternative to peas in the linPRO-R product formulation. However, the effects of linPro with peas or fava bean, particularly the FA composition of milk, have not been determined. Therefore, the objective of this study was to

The 3 supplements were manufactured by O&T Farms, Regina, Saskatchewan, Canada. O&T Farms manufactures and sells similar extruded products. One author is employed by O&T Farms. The other authors declare no conflict of interest.

[1] Corresponding author: david.christensen@usask.ca

evaluate the effects of the whole versus extruded flaxseed supplements and the use of tannin-containing fava beans as a replacement for peas in an extruded flaxseed-based supplement on rumen fermentation, selected milk FA, and production in dairy cows.

MATERIALS AND METHODS

Animal, Experimental Design, and Diets

Eight multiparous Holstein cows (712.7 ± 92.3 kg of BW; 116.5 ± 17.5 DIM at the beginning of the experiment) were used in a replicated 4 × 4 Latin square experimental design with 28-d periods consisting of 20 d of dietary adaptation and 8 d of sample and data collection. Four cows in one Latin square were fitted with permanent ruminal cannulas (Bar Diamond Inc., Parma, ID). All experimental procedures were approved by the University of Saskatchewan Animal Care Committee (UCACS Protocol No. 20040048) and were conducted in accordance with the Canadian Council of Animal Care (1993) guidelines. Cows were fed a control diet based on barley silage and alfalfa hay (48.1% of DM; **CONT**), a diet containing a nonextruded flaxseed and pea supplement (**FLX**), a diet containing a commercially available extruded flaxseed ingredient that uses peas as the main absorbent material (**EXT**; linPRO-R, O&T Farms), or a diet containing an extruded flaxseed ingredient that included tannin-containing fava beans as an alternative to peas (**EXTT**; O&T Farms). Ingredient and chemical composition of the flaxseed ingredients are described in Table 1. The ingredient and chemical composition of experimental diets are presented in Table 2, and a detailed list of the diets' FA composition is presented in Table 3. The CONT diet was based on a commercial diet that is commonly used by dairy producers in western Canada. The flaxseed supplements partially replaced the barley-based concentrate at 11.4% of DM, and the experimental diets containing flaxseed (i.e., the FLX, EXT, and EXTT diets) were formulated to be isoenergetic and isonitrogenous. Experimental diets were mixed into a TMR using a Data Ranger TMR Mixer (American Calan, Northwood, NH). The forage-to-concentrate ratio of the TMR was 50:50 (DM basis), with the forage component being a mixture of barley silage (~60% on a DM basis) and chopped alfalfa hay (~40%). The costs of flaxseed-supplemented diets were similar to that of the CONT diet (averaging 2.60 $/cow per day; Moats, 2016).

Sample Collection and Analyses

Cows were fed twice daily at 0930 and 1700 h for ad libitum intake (allowing ~5% orts). Dry matter intake was recorded daily throughout the experiment. Orts from all 8 cows were collected and weighed daily at 0900 h over the 8-d collection period for the determination of individual cow feed and FA intake. Orts were pooled per cow per period and stored at −20°C pending chemical analysis. To determine the chemical composition of the experimental diets fed to experimental cows, samples of the individual feed ingredients were collected on d 21 to 23 and stored at −20°C pending chemical analysis. Cows had free access to water.

Cows were milked 3 times daily at 0430, 1230 and 1900 h, and milk weights were recorded using a MM25 milk meter (DeLaval Canada, Peterborough, ON, Canada). Milk samples were collected at each milking over 3 consecutive days (d 26, 27, and 28 of each experimental period) into plastic vials containing 2-bromo-2-nitropropane-1-2-diol as a preservative. Daily milk samples were then pooled proportionally based on milk weights to form a single composite sample of 1,000 mL for each cow in each period. The composite sample was then subsampled, in duplicate, into vials containing 2-bromo-2-nitropropane-1-2-diol as a preservative and submitted to CanWest DHI Laboratory (Edmonton, AB, Canada) for analysis of milk fat, milk protein, milk lactose, milk urea nitrogen using a mid-infrared analyzer (Foss System 4000, Foss Electric, Hillerød, Denmark; AOAC, 1990; method 972.16), and SCC according to the Fossomatic Method (Foss System 4000, Foss Electric). Additional milk samples without preservative were collected in duplicate in 40-mL vials from the composite sample and submitted to Lipid Analytical Services Ltd. (Guelph, ON, Canada) for FA analysis, where fat extraction was conducted according to Bligh and Dyer (1959), with minor modifications as described by Alzahal et al. (2009). Quantification of FA methyl esters (**FAME**) was conducted using a Varian 3400 CX gas chromatography unit with a Varian 8200 injector (Allegiant Technologies, Mississauga, ON, Canada) using tridecanoin (C13:0) as an internal standard.

To quantify dietary effects on ruminal fermentation characteristics, ruminal contents were collected from the ruminally cannulated cows on d 27 and 28. A total of 250 mL of ruminal contents was collected from the cranial-dorsal, ventral-dorsal, caudal-dorsal, and ventral-dorsal sac of the rumen at 0900, 1000, 1100, 1200, 1300, 1600, 1900, and 2200 h on d 27 and 0100, 0400, and 0700 h on d 28 to yield a 1,000-mL composite sample. The composite sample was squeezed through 4 layers of cheesecloth, and pH of the filtrate was measured immediately using a portable pH meter (VWR Symphony SP70C; VWR Canada, Mississauga, ON, Canada). A 10-mL subsample of ruminal fluid was preserved in vials containing 2 mL of 25% (wt/vol) metaphosphoric acid (H_2PO_4) solution and stored at −20°C pending analysis of short-chain FA (**SCFA**). Ruminal SCFA samples were separated and quantified by gas chromatography (Agilent 6890, Mississauga, ON, Canada) as described by Khorasani et al. (1996). Another 10-mL subsample of ruminal fluid was preserved in vials containing 2 mL of 1% (wt/vol) sulfuric acid (H_2SO_4) solution and stored at −20°C pending determination of ammonia-nitrogen (NH_3-N) concentrations according to Broderick and Kang (1980).