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# Milk production and composition, milk fatty acid profile, and blood composition of dairy cows fed different proportions of whole flaxseed in the first half of lactation

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ABSTRACT

A total of 32 Holstein cows were allotted at calving to eight groups of four cows blocked to determine the effects of feeding increased levels of whole flaxseed (WF) in the diet on dry matter (DM) intake (DMI), milk production and composition, milk fatty acid (FA) profile, concentration of some blood metabolites and energy balance. Cows within each block were assigned to one of four iso-net energy for lactation total mixed rations: no whole flaxseed (0WF), and diets with preplanned inclusions of 50 (50WF), 100 (100WF) or 150 (150WF) g/kg DM WF. Diets were fed for *ad libitum* intake from calving to week 24 of lactation. There was a trend for an interaction between treatment and week for DMI, milk yield, and logsomatic cell count (P=0.08, 0.07, and 0.09, respectively). Values of DMI averaged for the 24 week experiment, yields of fat, protein and total solids and proportions of short- and medium-chain FA in milk fat decreased linearly with higher proportions of WF in the diet. Milk yield was similar among diets. Proportions of 18:0, *cis*9-18:1, *trans*9-18:1, *cis*9,*trans*11-18:2, *cis*9,12,15-18:3 19:0 and 20:0 in milk fat increased linearly and those of *cis*9,12-18:2, *trans*9,12-18:2 and 20:4 decreased linearly with higher concentrations of WF in the diet. Although milk FA profile was enhanced, feeding more than preplanned inclusions of 50 g/kg DM WF had negative effects on yield of milk components.



## 1. Introduction

Flaxseed (*Linum usitatissimum*) supplementation has been shown to decrease embryo mortality in dairy cows (Petit and Twagiramungu, 2006). Feeding whole flaxseed (WF) during the transition period also contributes to decrease the incidence of the fatty liver syndrome as suggested by higher and lower concentrations of glycogen and triglycerides, respectively, in the liver of multiparous cows after calving (Petit et al., 2007). Indeed, flaxseed is likely a glucogenic energy source (Van Knegsel et al., 2007), thus it has the potential to reduce the risk for metabolic disorders in dairy cows. Most experiments on flaxseed have been short-term trials with less than 2 months or studies with processed flaxseed (*e.g.*, extruded, rolled, ground) and the optimum level of WF to incorporate in the dietary dry matter (DM) of cows from calving through the first half of lactation

*Abbreviations:* ADF, acid detergent fiber; DM, dry matter; DMI, dry matter intake; FA, fatty acid; aNDF, neutral detergent fiber; NEFA, non-esterified fatty acids; TMR, total mixed ration; TTAD, total tract digestibility; WF, whole flaxseed; 0WF, diet with 0 g/kg DM whole flaxseed; 50WF, diet with 50 g/kg DM whole flaxseed; 100WF, diet with 100 g/kg DM whole flaxseed; 150WF, diet with 150 g/kg DM whole flaxseed.

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is unknown. Thus, there is a need to provide more information on feeding WF for longer periods. Flaxseed is a good source of fat (314 g/kg DM; Petit, 2002). Rabiee et al. (2012) have recently reported that the final meta-regression model for DM intake (DMI) indicated that feeding fat for a longer period increased DMI, thus emphasizing the need for further long term experiments on fat (*e.g.*, flaxseed) supplementation. Therefore, the objective of this experiment was to determine the effects of feeding different proportions of WF on performance (*i.e.*, feed intake, milk production and milk composition) of dairy cows through the first half of lactation (24 weeks) and blood parameters related to the fatty liver syndrome during early lactation. Milk fatty acid (FA) profile also was examined. The hypothesis was that increasing levels of WF in the diet has no effect on performance of dairy cows.

## 2. Materials and methods

### 2.1. Cows, experimental design, and diets

The experiment was carried out at the Atlantic Dairy and Forage Institute (ADFI) of Fredericton Junction, NB, Canada, from May 2011 to February 2012 using 28 multiparous and 4 primiparous Holstein cows. The experiment was conducted from calving to week 24 of lactation (first half of lactation). Cows were blocked (4 cows per group) by parity and for calving dates expected within a 4 week period. There were 7 blocks of multiparous cows and one block of primiparous cows. Cows within groups were assigned randomly to one of four total mixed rations (TMR; Table 1) that consisted of a control TMR with no WF (0WF), and TMR with preplanned inclusions of 50 (50WF), 100 (100WF) or 150 (150WF) g/kg DM WF. All diets were designed to have similar concentrations of crude protein and net energy for lactation. Cows were housed in tie stalls and fed individually. Diets were fed twice daily at 07:00 and 15:00 h at *ad libitum* rates to allow 100 g/kg refusals and consumption was recorded daily. Cows were milked twice daily at 05:45 and 16:45 h and production was recorded at every milking. Cows were cared for in accordance with guidelines of the Canadian Council on Animal Care (CCAC, 1993). The body weight of each cow was determined weekly for the first 8 weeks of lactation and every 4 weeks afterwards.

Total collection of feces was carried out on week 10 of lactation from the first 8 blocks of cows to calve for determination of total tract apparent digestibility (TTAD). Milk yield and DMI are less variable after the lactation peak, which was the rationale behind the choice of week 10 of lactation for TTAD measurement. Feces were collected from a rubber mat placed behind the

**Table 1**
Ingredient and actual chemical composition of total mixed diets of Holstein cows fed no flaxseed (0WH), 50 g/kg dry matter (DM) whole flaxseed (50WF), 100 g/kg DM whole flaxseed (100WF) or 150 g/kg DM whole flaxseed (150WF).[a]

| | Treatment | | | |
|---|---|---|---|---|
| | 0WF | 50WF | 100WF | 150WF |
| Ingredient composition (g/kg DM) | | | | |
| Corn silage | 273 | 265 | 265 | 265 |
| Haylage[b] | 265 | 285 | 285 | 274 |
| Barley, grain (rolled) | 89 | 89 | 88 | 87 |
| Corn, grain (ground) | 190 | 141 | 105 | 80 |
| Soybean, meal (480 g/kg crude protein, solvent) | 148 | 138 | 129 | 120 |
| Flaxseed, whole | 0 | 46 | 93 | 139 |
| Megalac[c] | 5 | 7 | 7 | 6 |
| Limestone | 6 | 5 | 5 | 5 |
| Mineral and vitamin supplement[d] | 24 | 24 | 23 | 24 |
| Chemical composition (g/kg DM) | | | | |
| Crude protein | 17.4 | 17.6 | 17.4 | 17.6 |
| Neutral-detergent fiber, ash free | 35.9 | 36.1 | 35.9 | 35.8 |
| Acid-detergent fiber, ash free | 21.4 | 22.7 | 22.0 | 23.0 |
| Net energy for lactation (MJ/kg DM)[e] | 6.90 | 6.90 | 6.90 | 6.90 |
| Fatty acid (g/kg DM)[f] | | | | |
| 14:0 | 0.1 | 0.1 | 0.1 | 0.2 |
| 16:0 | 5.6 | 7.3 | 8.4 | 9.7 |
| 18:0 | 0.7 | 1.4 | 1.9 | 2.5 |
| *cis*9 18:1 | 5.1 | 8.9 | 11.9 | 14.6 |
| *cis*6 18:2 | 10.0 | 12.5 | 13.5 | 15.1 |
| *cis*3 18:3 | 4.4 | 13.3 | 21.6 | 27.9 |
| Total fatty acids | 26.4 | 44.5 | 59.0 | 71.2 |

[a] Mean of 10 monthly samples prepared by compositing weekly samples.
[b] Timothy grass.
[c] Church and Dwight Co. Inc., Princeton, NJ, USA.
[d] Contained (as fed basis) 143 g/kg of Ca, 23 g/kg of P, 65 g/kg of Mg, 15 g/kg of S, 55 g/kg of Na, 7 g/kg of K, 984 mg/kg Fe, 1772 mg/kg Zn, 496 mg/kg Cu, 1784 mg Mn, 33 mg/kg I, 53 mg/kg Co, 14 mg/kg Se, 256.990 IU/kg of vitamin A, 77,100 UI/kg of vitamin $D_3$, and 1697 IU/kg of vitamin E.
[e] Calculated using published values of feed ingredients (NRC, 2001).
[f] Mean of pool sample from eight samples prepared by compositing pool samples from seven daily samples collected from eight cows per diet during week 10 of lactation.