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Production performance and milk composition of dairy cows fed different concentrations of flax hulls

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ABSTRACT

A total of 45 lactating Holstein cows averaging 617 kg of body weight (SE = 20.6) were allotted at week 20 of lactation to five groups of nine cows blocked for similar days in milk to determine the effects of feeding different concentrations of flax hulls on dry matter (DM) intake, milk production, milk composition, digestion, and milk concentration of the mammalian lignan enterolactone. Cows within each block were assigned to one of the five isoenergetic total mixed diets containing either 0, 50, 100, 150, or 200 g/kg DM flax hulls (FHs). The experiment was carried out from wk 20 to 24 of lactation and diets were fed for *ad libitum* intake. Concentration of FH in the diet had no effect on milk yield, proportions of protein and fat and yields of protein, fat and lactose. There was a linear increase in proportion of lactose in milk and a quadratic effect of feeding level of flax hulls on somatic cell count. Total tract apparent digestibility of DM, acid detergent fiber (ADF), and neutral detergent fiber (aNDF) was similar among diets. Total tract apparent digestibility of ether extract increased with higher proportions of flax hulls in the diet and the increase was more important from 0 to 50 g/kg DM flax hulls. Moreover, milk proportions of total *trans*, monounsaturated and polyunsaturated fatty acids and concentration of the mammalian lignan enterolactone increased with greater concentration of flax hulls in the diet while the inverse was observed for proportions of saturated fatty acids. Flax hull supplementation may then contribute to the modification of milk composition for better human health with no detrimental effect on productivity of dairy cows.

1. Introduction

Flaxseed (*Linum usitatissimum*) is one of the richest sources of the plant lignan precursor secoisolariciresinol diglucoside (SDG; Axelson et al., 1982). In non-ruminant animals, microbial enzymes convert plant lignan precursors to mammalian lignans, mainly enterodiol and enterolactone (EL; Setchell et al., 1980). In ruminant animals, the conversion of SDG in EL occurs mainly under the action of the ruminal microbiota (Gagnon et al., 2009). Enterolactone is the main mammalian lignan present in milk and results have shown that people with higher blood concentrations of EL have lower incidence of cardiovascular diseases (Vanharanta et al., 1999). In addition to their healthy effects, SDG and its mammalian lignan metabolites have greater antioxidant activity than vitamin E (Kitts et al., 1999), which could be a tool to decrease milk oxidation and produce value-added milk with health benefits.

Abbreviations: ADF, acid detergent fiber; aNDF, neutral detergent fiber; DM, dry matter; EL, enterolactone; FA, fatty acid; FH, flax hulls; NE_L, net energy for lactation; SDG, secoisolariciresinol diglucoside; TMR, total mixed ration.

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Flax hull, a commercial co-product obtained from flax processing (Natunola Health Inc., Nepean, ON, Canada), is an interesting feed ingredient for the diet of dairy cows as shown by its crude protein and ether extract concentrations (240 and 300 g/kg dry matter [DM], respectively; Gagnon et al., 2009) and proportion of linolenic acid (529 g/kg of total fatty acids; Kazama et al., 2010). As flax hulls contain higher concentration of SDG than whole seeds (24–40 g/kg DM *versus* 10.6 g/kg DM; Côrtes et al., 2008), incorporation of increased amounts of flax hulls in the diet may enhance milk concentration of EL. Indeed, flax hull has increased EL concentration in milk of cows when fed at 200 g/kg DM with no effect on yield of milk corrected for 40 g of fat per kg of milk although supplementing flax hulls decreased DM intake (Petit et al., 2009). Although flax hulls may then contribute to increase concentration of the mammalian lignan EL in milk there is little information on the use of flax hulls for dairy production. Therefore, the objectives of the experiment were to determine the effects of feeding different concentrations of flax hulls in the diet of dairy cows on milk concentration of EL. Because information about the effect of proportion of flax hulls in the diet of dairy cows was limited, feed intake, digestion, milk production, and milk composition for each dietary concentration of flax hulls were also determined.

2. Materials and methods

2.1. Cows, experimental design, and diets

The experiment was conducted at the Atlantic Dairy and Forage Institute of Fredericton Junction, NB, Canada, from November 2005 to April 2008 using 35 multiparous and 10 primiparous Holstein cows averaging 617 kg of body weight (SE = 20.6). Cows were blocked for similar days in milk within parity. The experiment was conducted from wk 20 to wk 24 of lactation. Cows were housed in tie stalls, fed individually, and milked twice daily at 06:15 and 15:30 h. Milk production was recorded at every milking. Cows within blocks were assigned randomly to one of five dietary treatments based on a mixture of silages (Table 1). The five total mixed rations (TMR; Table 1) contained 0, 50, 100, 150, or 200 g/kg DM flax hulls (FHs); in the dietary DM. All diets were formulated to meet requirements for cows that averaged 620 kg of body weight and produced 30 kg/d of milk with 40 g/kg fat (NRC, 2001). Cows were cared for in accordance with guidelines of the Canadian Council on Animal Care (CCAC, 1993).

Table 1
Ingredients and chemical composition of total mixed diets of Holstein cows fed 0, 50, 100, 15, or 200 g/kg of flaxseed hulls (FHs) in the dry matter (DM).

	Treatment						*P* value	
	0FH	50FH	100FH	150FH	200FH	SEM	Linear	Quadratic
Ingredients (g/kg DM)								
Grass silage	335	315	325	317	313			
Corn silage	317	299	307	301	297			
Ground corn	83	83	62	54	42			
Barley	125	126	97	80	63			
Soybean meal	97	88	79	71	62			
Flaxseed hulls	0	46	92	139	185			
Mineral and vitamin supplement[a]	38	38	33	33	33			
Urea	5	5	5	5	5			
Chemical analysis (g/kg DM)								
Crude protein	158.4	163.3	166.4	161.5	167.4	2.14	0.02	0.45
Ether extract	24.7	30.2	36.5	42.9	53.8	1.86	<0.001	0.12
Neutral detergent fiber (aNDF)	358.7	358.1	389.7	385.5	381.9	8.79	0.01	0.21
Acid detergent fiber (ADF)	224.4	226.1	246.9	249.0	247.7	6.41	0.31	0.27
NE_L (MJ/kg of DM)[b]	6.73	6.73	6.77	6.77	6.77			
Fatty acids (g/kg total fatty acids)[c]								
16:0	156	152	134	128	117			
18:0	35	34	31	28	26			
*cis*9-18:1	148	142	145	145	150			
*cis*6-18:2	316	290	244	236	211			
*cis*3-18:3	278	322	401	425	459			
20:0	6	5	4	2	3			
*cis*5-20:1	2	2	2	2	2			
20:2	2	1	2	2	1			
*cis*6-20:4	2	1	1	1	1			
22:0	6	6	5	4	3			
22:2	6	5	4	2	3			
22:5	4	2	2	1	1			

[a] Contained (g/kg, as-is basis): Ca 270 g, P 80 g, Mg 20 g, S 20 g, Fe 2200 mg, Zn 2800 mg, F 801 mg, I 60 mg, Co 50 mg, Mn 2850 mg, Cu 354 mg, Fe 2154 mg, Se 15 mg, vitamin A 85,701 IU, vitamin D 85,500 IU, and vitamin E 1425 IU.
[b] Calculated using published values of feed ingredients (NRC, 2001).
[c] Mean of one pool made from seven daily samples collected from each cow during the digestibility trial.