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Composition of flaxseed recovered from the faeces of dairy cows fed different proportions of whole flaxseed in the diet

C. Côrtes[a,1], R. Kazama[b,2], D. da Silva-Kazama[b,2], G.T.D. Santos[b], L.M. Zeoula[b], H.V. Petit[a,*]

[a] Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada, 2000, College Street, Sherbrooke, QC, Canada J1M OC3

[b] Departamento de Zootecnia, Universidade Estadual de Maringa, Maringa, PR, Brazil

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ABSTRACT

Three multiparous lactating Holstein cows averaging 699 kg of body weight (SE = 76.2) were allotted in a 3 × 3 Latin square design to determine the nutrient profile of flaxseed recovered from the faeces of dairy cows fed different amounts of whole flaxseed and to compare the chemical composition of dietary flaxseed to that of flaxseed recovered from faeces. The three dietary treatments consisted of three total mixed diets containing 50, 75 or 100 g/kg dry matter (DM) whole flaxseed. Milk production, milk composition and total tract apparent digestibility (TTAD) were also determined. Intake of DM, milk yield and composition, production of milk components and TTAD of acid detergent fibre (ADF) and ether extract (EE) were similar among treatments. Total tract apparent digestibility of DM and crude protein (CP) decreased linearly with higher concentration of whole flaxseed in the diet and TTAD of neutral detergent fibre (aNDF) was quadratically affected. Composition of flaxseed recovered from the faeces of cows fed the three diets was generally similar. Concentrations of CP and EE in flaxseed recovered from the faeces were lower and higher, respectively, compared to those of flaxseed consumed by cows and there was no difference in aNDF and ADF concentrations. Proportions of 14:0, 15:0, 16:0, 17:0, *trans*11-18:1, *cis*9,*trans*11-18:2, and 20:0 in flaxseed recovered from the faeces decreased linearly with greater proportions of dietary flaxseed and that of *cis*9,12,15-18:3 increased. Proportions of 16:0 and *cis*9-16:1 decreased linearly and those of trans9-18:1, *trans*13+14-18:1+*cis*6+8-18:1, 19:0, *cis*9,*cis*12,*cis*15-18:3 increased linearly in milk fat with higher amounts of whole flaxseed in the diet. The amount of flaxseed recovered in faeces increased in parallel with the amount consumed. However, the linear decrease in TTAD of DM and CP with increasing proportion of whole flaxseed in the diet and the trend for better TTAD of aNDF for cows fed 50 g/kg DM than for those fed greater amounts of whole flaxseed suggest that productivity of dairy cows could be negatively affected when feeding more than 50 g/kg DM whole flaxseed.

Abbreviations: ADF, acid detergent fibre; CP, crude protein; DM, dry matter; EE, ether extract; FA, fatty acids; aNDF, neutral detergent fibre; NEL, net energy for lactation; TTAD, total tract apparent digestibility.

* Corresponding author. Tel.: +1 819 780 7210; fax: +1 819 564 5507.
E-mail address: helene.petit@agr.gc.ca (H.V. Petit).

[1] Present address: Département de Productions Animales, Unité de Recherche Systèmes d'Élevage, École Supérieure d'Agriculture d'Angers, Angers 49007, France.

[2] Present address: Departamento de Zootecnia e Desenvolvimento Rural, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil.

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1. Introduction

Processing of some grains is required to ensure adequate digestion by cattle, although the extent of processing required may depend on the amount of physical damage by the animal during mastication (Beauchemin et al., 1994). Processing is expensive and may result in a substantial increase in feed costs. Processing such as grinding may increase the release of oil from the seed (Murphy et al., 1990) and biohydrogenation of polyunsaturated fatty acids (FA) into the rumen, thus lowering absorption of these FA in the small intestine and their transfer in milk fat. However, the extent of biohydrogenation depends on the hardness of the hull and on the particle size (whole-grain *versus* rolled *versus* ground), and the extent of mastication that breaks the oilseed hulls (Doreau et al., 2011). Therefore, damage to seeds during mastication or rumination may contribute to make physical processing unnecessary, thus reducing feeding costs.

Flaxseed (*Linum usitatissimum*) contains about 349 g/kg dry matter (DM) fat, 235 g/kg DM crude protein (CP), and 207 g/kg DM neutral detergent fibre (aNDF; Petit and Gagnon, 2009a), which makes it an attractive feed ingredient for inclusion in lactating dairy cows rations as a source of both energy and protein. Flaxseed also contains a high oil level (400 g/kg of total seed weight), with α-linolenic acid (*cis*9,12,15-18:3) constituting approximately 550 g/kg of total fatty acids (FA) of the oil (Glasser et al., 2008). However, there is still controversy regarding the importance of flaxseed processing and results of studies concerning digestibility of flaxseed-supplemented diets have been inconclusive. For example, digestibility of dairy cow diets containing whole flaxseed compared to digestibility of control diets with no flaxseed has been reported to be lower (Martin et al., 2008) or similar (Petit and Gagnon, 2009b; Schroeder et al., 2014) and the process of extrusion increased it (Martin et al., 2008). Providing flaxseed twice daily in the study of Martin et al. (2008) may have contributed to a high decrease in digestibility, because the effects on digestibility have been less in a study where cows were fed 3 times daily a diet with 30 g/kg DM flaxseed oil (Ueda et al., 2003). Maddock et al. (2006) recommended that processing such as rolling or grinding was performed to improve digestion of flaxseeds incorporated in feedlot diets of beef cattle. In addition, Martin et al. (2008) speculated that the negative effect of lipids on digestion was more pronounced with corn silage diets than with hay diets and they concluded that the amount of added lipids and their form of presentation (oil *versus* seed) were the major determining factors for the negative effect of flaxseed FA on digestibility. Therefore, no clear relationship could be established between total tract apparent digestibility (TTAD) and the amounts of flaxseed fed because many factors such type of forage and processing of flaxseed can explain discrepancies in TTAD between experiments. Although the presence of whole flaxseeds in faeces of dairy cows has previously been reported (Oba et al., 2009), it is unknown if they still contain any nutrients and are responsible for any decrease in digestibility of a forage-based diet. Therefore, the objectives of the experiment were to determine the nutrient profile of flaxseed recovered from the faeces of dairy cows fed different amounts of whole flaxseed in a high-forage diet and to compare the chemical composition of dietary flaxseed to that of flaxseed recovered from faeces. The amount of flaxseed recovered in the faeces, milk production, milk composition and TTAD were also determined to look at any potential link between faecal excretion of flaxseed and productivity of dairy cows.

2. Materials and methods

2.1. Cows, experimental design, and diets

The experiment was conducted at the Dairy and Swine Research and Development Centre of Sherbrooke, QC, Canada, using 3 multiparous (initial body weight: 699 ± 76.2 kg) Holstein cows averaging 170 ± 12.2 days in lactation. Animals were cared for according to official guidelines (Canadian Council on Animal Care, 1993). 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 were assigned to a 3 × 3 Latin square design with three treatments and three periods. Each experimental period consisted of 14 days of adaptation to the dietary treatments. Feed intake and milk yield were measured daily from day 15 to 20 of each period. The three dietary treatments consisted of three total mixed diets (Table 1) containing 50, 75 or 100 g/kg DM whole flaxseed. The diets were formulated to meet requirements for cows that averaged 700 kg of BW and produced 30 kg/day of milk with 39 g/kg of fat (NRC, 2001).

2.2. Sample collection

Diets were fed twice daily at 06:00 and 14:00 h at *ad libitum* rates to allow 100 g/kg refusals. Feed consumption was recorded daily. The diets and flaxseed were sampled daily on day 15–20, frozen, and composited on a 6 day basis. Composited samples were mixed thoroughly and subsampled for chemical analyses. Milk samples were obtained daily from each cow for 10 consecutive milkings and were composited on a yield basis to determine milk composition. Milk samples were kept at room temperature with a preservative (bronopol-B2) for determination of protein, fat, urea, and lactose concentrations and somatic cell counts. One sample without preservative was kept frozen to determine milk FA profile concentration.

Cows were dosed from day 11 to 20 with chromic oxide (10 g in gelatine capsules) once daily at 16:30 h *via* the ruminal cannula. Faecal grab samples were taken directly from the rectum of each cow twice daily at 08:30 and 16:30 h (approximately 600 g at each sampling time) on the last 5 days of each experimental period. Sampling of faecal samples twice daily at fixed time has been performed before to determine digestibility of the diet (Oellermann et al., 1990; Moreira et al., 2004). One portion was dried at 55 °C and ground through a 1 mm screen (Arthur H. Thomas, Philadelphia, PA, USA) for Cr