Animal Feed Science and Technology 169 (2011) 270–274

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Short communication

Intake and digestion of fatty acids by dairy cows fed whole flaxseed and Ca salts of flaxseed oil

C. Côrtes[a,1], D.C. da Silva-Kazama[b,2], R. Kazama[b,2], C. Benchaar[a], 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, P. O. Box 90, Stn Lennoxville, Sherbrooke, QC J1M 1Z3, Canada
[b] Departamento de Zootecnia, Universidade Estadual de Maringa, Maringa, PR, Brazil

ARTICLE INFO

Article history:
Received 17 January 2011
Received in revised form 15 June 2011
Accepted 21 June 2011

Keywords:
Dairy cattle
Fatty acids
Milk quality

ABSTRACT

Four ruminally lactating Holstein cows averaging 602 kg of body weight and 64 days in milk were randomly assigned to a 4 × 4 Latin square design to determine the effects of feeding whole flaxseed and calcium salts of flaxseed oil on intake and total tract apparent digestibility (TTAD) of fatty acids (FA) and apparent transfer of linolenic acid in milk fat. The treatments were for *ad libitum* intake: a control diet with no flaxseed products (CON) or a diet of 42 g/kg dry matter (DM) whole flaxseed (FLA), 19 g/kg DM calcium salts of flaxseed oil (SAL) or 23 g/kg DM whole flaxseed and 8 g/kg DM calcium salts of flaxseed oil (MIX). Experimental periods consisted of 21 d of diet adaptation and 7 d of data collection and sampling. Intake of α-linolenic acid (*cis*9,12,15-18:3) was similar for cows fed FLA, SAL, and MIX and higher than for those fed CON. Output of linolenic acid in faeces was higher for cows fed FLA, followed by those fed MIX, CON, and SAL. Output of α-linolenic acid in milk tended (P=0.07) to be lower for cows fed CON than for those fed the other diets and there was no difference between cows fed FLA, SAL, and MIX. Although intake of α-linolenic acid was lower for cows fed CON than for those fed the other diets, transfer efficiency (g per 100 g of α-linolenic acid consumed) was higher for cows fed the former diet. Feeding FLA, SAL, and MIX resulted in similar apparent transfer of α-linolenic acid in milk. Cows fed FLA had the lowest TTAD of linolenic acid. The high digestibility of Ca-salts of flaxseed oil accounts for the interest in using it in practical applications for feeding cows. However, as previous results have shown that the use of Ca-salts of flaxseed oil did not allow a large modification in milk fat composition, the cheapest flaxseed product will be recommended to incorporate in the dairy cow diet.

Abbreviations: CON, control diet with no flaxseed products; DM, dry matter; FA, fatty acids; FLA, diet with 42 g/kg DM whole flaxseed; MIX, diet with 23 g/kg DM whole flaxseed and 8 g/kg DM calcium salts of flaxseed oil; PUFA, polyunsaturated fatty acids; SAL, diet with 19 g/kg DM calcium salts of flaxseed oil; TTAD, total tract apparent digestibility.

* Corresponding author. Tel.: +1 819 780 7210; fax: +1 819 564 5507.
E-mail addresses: helene.petit@agr.gc.ca, petith@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.

0377-8401/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.anifeedsci.2011.06.016

1. Introduction

Minimizing ruminal biohydrogenation of polyunsaturated fatty acids (PUFA) is the major challenge in formulating dietary supplements that will enhance the postruminal supply of PUFA. One method of protection has been through the use of calcium salts (Ca-salts) of FA that were developed to reduce the negative effects of fat on ruminal fermentation (Ferlay et al., 1992). Wu et al. (1991) calculated that ruminal biohydrogenation of 18-carbon unsaturated FA averaged 0.87 for an unprotected animal-vegetable blend fat supplement and 0.57 for Ca-salts of FA. However, the extent of ruminal biohydrogenation increased as the number of double bonds increased and the difference between unprotected and Ca-protected unsaturated FA was reduced; for example, biohydrogenation of 18:3 averaged 0.84 for the unprotected supplement and 0.80 for the Ca-protected supplement (Wu et al., 1991). As flaxseed is rich in α-linolenic acid, Ca-salts of flaxseed oil would be an option to increase *n*-3 FA concentration in milk fat. Indeed, feeding four doses (0, 18.4, 35.4 or 54.0 g/kg dry matter; DM) of Ca-salts of flaxseed oil in the DM to dairy cows has been reported to increase proportions of *n*-3 FA from 12.0 to 22.5 g/kg of FA (Brzóska, 2006). Moreover, our previous results (Côrtes et al., 2010) have shown that concentration of α-linolenic acid was higher in milk fat of cows fed Ca-salts of flaxseed oil or a mixture of Ca-salts of flaxseed oil and whole flaxseed than in milk of cows fed a control diet with no flaxseed product (75% and 61%, respectively). However, there is no information on digestive utilization of FA and transfer efficiency of α-linolenic acid from the diet into milk. Therefore, the objective of the experiment was to compare diets providing similar α-linolenic acid amounts supplied by a natural feed ingredient (whole flaxseed), a protected oil (Ca-salts of flaxseed oil) or a combination of both on intake and total tract apparent digestibility (TTAD) of FA, and apparent transfer of α-linolenic acid in milk fat.

2. Materials and methods

2.1. Cows, experimental design, and diets

The present study is part of a larger project concerning milk production, FA profile of ruminal fluid and milk fat, ruminal fermentation characteristics, and TTAD of nutrients reported elsewhere (Côrtes et al., 2010). Four lactating primiparous Holstein cows fitted with ruminal cannulas (10 cm, Bar Diamond Inc., Parma, ID, USA) were used in a 4 × 4 Latin square design with four 28-d periods. Ingredients and chemical composition of the diets and feeding management were as described by Côrtes et al. (2010). Cows were fed a total mixed diet with no flaxseed products (control, CON), or diets of 42 g/kg DM whole unprocessed flaxseed (FLA) (AOAC, 1990), 19 g/kg DM Ca-salts of flaxseed oil (SAL) or 23 g/kg DM whole unprocessed flaxseed and 8 g/kg DM Ca-salts of flaxseed oil (MIX). The Ca-salts supplement was supplied by Virtus Nutrition Inc. (Corcoran, CA, USA) and the amount added to the SAL diet was based on recommendation made by the manufacturer (Virtus Nutrition Inc.). The four isonitrogenous and isoenergetic total mixed diets were based mainly on grass silage (277, 277, 308 and 287 g/kg of DM for CON, FLA, SAL and MIX, respectively), corn silage (278, 277, 208 and 287 g/kg of DM for CON, FLA, SAL and MIX, respectively), cracked corn grain (216, 197, 144 and 180 g/kg of DM for CON, FLA, SAL and MIX, respectively), ground barley (73, 72, 73 and 73 g/kg of DM for CON, FLA, SAL and MIX, respectively), and soybean meal (75, 59, 75 and 71 g/kg of DM for CON, FLA, SAL and MIX, respectively). The cows were kept in individual stalls and had free access to water. The cows averaged 64 ± 6 days in milk at the start of the experiment with an average body weight of 602 ± 25 kg. Diets were offered in equal amounts twice daily at 08:30 and 15:30 h for *ad libitum* rates to allow 100 g/kg refusals and cows were milked twice daily at 08:00 and 19:00 h. National guidelines for the care and use of animals were followed as recommended by the CCAC (1993) (Canadian Council on Animal Care).

2.2. Experimental procedures

Each experimental period consisted of 21 d of adaptation to the diets and 6 d of data collection and sampling. Feed intake and milk yield were measured daily and data on milk yield has been published previously (Côrtes et al., 2010). On d 20, cows were fitted with harnesses and tubes allowing total collection of faeces and urine separately. From d 21 to 27, faeces were collected from a rubber mat placed behind the animals and stored in plastic containers. Daily faeces were weighed and mixed thoroughly and a subsample (2 g/100 g) was taken and stored at −20 °C for subsequent freeze drying. Samples of the four diets were taken daily from d 21 to 28 and pooled within period for each cow. All samples were frozen at −20 °C for subsequent drying at 55 °C.

2.3. Chemical analysis

Dry matter of the diets and faeces were determined in a forced-air oven according to the procedure 934.01 (AOAC, 1990). Total mixed dried diets and freeze-dried faeces were ground to pass a 1-mm screen in a Wiley mill before analyses of FA. Extraction of fat in diets, milk, and faeces, FA methylation and identification of individual FA in milk, diets and faeces was done using methods described by Côrtes et al. (2010).