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Interaction of sunflower oil with monensin on milk composition, milk fatty acid profile, digestion, and ruminal fermentation in dairy cows

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ABSTRACT

Four ruminally fistulated multiparous Holstein cows were assigned to a 4 × 4 Latin square design to determine the interaction between sunflower oil and monensin supplementation on intake, milk production, total apparent digestibility of the diet (TTAD), ruminal fermentation characteristics and milk fatty acid profile. The experimental diets consisted of a 2 × 2 factorial arrangement of treatments: (1) control (no sunflower oil and no monensin; CON), (2) diet containing (dry matter (DM) basis) 42 g/kg sunflower oil (OIL), (3) control with monensin (16 mg/kg of DM; MON), and (4) diet containing (DM basis) 42 g/kg sunflower oil and 16 mg/kg monensin (MIX). Sunflower oil supplementation tended to decrease DM intake and yield of milk fat. Sunflower oil decreased milk urea N concentration likely as a result of better N utilization, suggesting that sunflower oil contributes to decrease deamination and amount of amino acids used for gluconeogenesis. There were interactions between monensin and oil supplementation for acetate, propionate, and the acetate to propionate ratio in the rumen as a result of lower proportion of acetate and higher proportion of propionate for cows fed MON compared to those fed CON. Molar proportions of butyrate and isobutyrate in the rumen were decreased by monensin and proportion of butyrate was increased by oil. There was no interaction between monensin and oil for milk FA profile. Sunflower oil supplementation decreased proportions of all short-chain and most medium-chain FA. Compared with cows fed no oil, those supplemented with sunflower oil had higher proportions of total *trans* FA and monensin had no effect. This study suggests that supplementing dairy cow diets containing a corn-based concentrate with a combination of monensin and sunflower oil adds no further improvements in milk FA profile to supplementing sunflower oil alone although the lack of effect on parameters with large numerical changes such as DM intake and milk yield should be confirmed using more animals.

Abbreviations: ADF, acid detergent fiber; BW, body weight; CLA, conjugated linoleic acid; CON, diet with no monensin and no sunflower oil; CP, crude protein; DM, dry matter; EE, ether extract; FA, fatty acids; MIX, diet with 42 g/kg sunflower oil and 16 mg/kg monensin; MON, control with 16 mg/kg monensin; aNDF, neutral detergent fiber; OIL, diet with 42 g/kg sunflower oil; SSC, somatic cell count; TTAD, total tract apparent digestibility; VFA, volatile fatty acids.

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1. Introduction

Rumenic acid (*cis*9,*trans*11-18:2), the major isomer of conjugated linoleic acid (CLA) in ruminant milk fat, exhibits anti-carcinogenic and antiatherogenic properties in animal models (Wahle et al., 2004). Diets supplemented with a source of polyunsaturated fatty acids (FA) such as linoleic acid and linolenic acid undergo biohydrogenation, resulting in the formation of *cis*9,*trans*11-18:2, *trans*11-18:1 and other isomers in the rumen. Milk CLA is derived from rumen CLA and endogenous synthesis of CLA from *trans*11-18:1 via stearoyl-CoA desaturase in the mammary gland (Griinari et al., 2000). However, studies have shown that increases in milk fat *cis*9,*trans*11-18:2 proportion to abomasal infusions of a mixture of FA containing *trans*11-18:1 are equivalent to proportionately 0.21 of the response to *cis*9,*trans*11-18:2 infusions (Shingfield et al., 2007). These findings indicate that enhancing the formation and accumulation of *cis*9,*trans*11-18:2 CLA in the rumen represents one mean to increase the concentration of this FA in milk fat. Sunflower seed is rich in linoleic acid (660 g/kg of the total FA) and increases the proportion of CLA in milk fat (Mohammed et al., 2011), likely as a result of higher ruminal outflow rate of *trans*11-18 and *cis*9,*trans*11-18:2 CLA following sunflower oil supplementation (Shingfield et al., 2008). Sunflower oil supplementation may then contribute to increase the proportions of total *trans* FA and *cis*9,*trans*11-18:2 CLA in milk fat.

Monensin has been shown to increase total CLA proportion in milk fat of dairy cows (Bell et al., 2006). Moreover, a combination of ground flaxseed and monensin resulted in higher milk fat concentration of *trans*11-18:1 than when feeding ground flaxseed without monensin or whole flaxseed with or without monensin (Da Silva et al., 2007). A greater oil release with ground rather than whole seed may explain the higher *trans*11-18:1 proportion in milk fat observed in the experiment of Da Silva et al. (2007), thus suggesting that free oil may lead to similar *trans*11-18:1 proportion increases when supplemented with monensin. Indeed, monensin interacts with soybean oil to linearly increase concentration of total *trans*11-18:1 in milk fat (Alzahal et al., 2008). Similar increases in milk fat total *trans*11-18:1 proportion has been reported with the combination of safflower oil and monensin (Bell et al., 2006). Besides its high concentration in linolenic acid, sunflower oil is highly effective in reducing both protozoa numbers and ammonia N concentrations in rumen fluid (Ivan et al., 2003), which would improve N utilization by cows. Therefore, a combination of sunflower oil and monensin would be interesting to increase beneficial FA in milk fat and improve N utilization. The hypothesis was that monensin and sunflower oil interacts to result in the highest proportions of total *trans* 18:1 and *cis*9,*trans*11-18:2 CLA in milk fat and best utilization of dietary N. The main objective of the experiment was to determine the effect of feeding a combination of sunflower oil and monensin on feed intake, milk production and composition, digestibility, ruminal fermentation characteristics and FA profile of milk.

2. Materials and methods

2.1. Cows and diets

Four ruminally fistulated multiparous Holstein cows averaging 643 ± 49.1 (mean ± SEM) kg of body weight and 95 ± 2.2 days in milk were assigned to a 4 × 4 Latin square design balanced for residual effect with four 28 d periods to determine the effects of sunflower oil and monensin supplementation on intake, milk production, total tract apparent digestibility of the diet (TTAD), ruminal fermentation characteristics and milk FA profile. The experimental diets (Table 1) consisted of four different total mixed diets with a 2 × 2 factorial arrangement of treatments: (1) control (no sunflower oil and no monensin; CON), (2) diet containing (dry matter (DM) basis) 42 g/kg sunflower oil (OIL), (3) control with monensin (16 mg/kg; MON), and (4) diet containing (DM basis) 42 g/kg sunflower oil and 16 mg/kg monensin (MIX). All diets provided equal amounts of crude protein (CP) and were formulated to meet nutrient requirements of 650 kg cow producing 35 kg/d of milk containing 38 g/kg fat (NRC, 2001). Cows were housed in tie stalls, fed individually for ad libitum intake (10% refusals) twice a day (08:30 and 15:30 h), and milked twice daily at 08:00 and 19:00 h. Milk production was recorded at every milking and feed intake was measured daily. Sunflower oil (Brenntag Canada, Inc., Toronto, ON, Canada) contained, expressed in g/kg of total FA, 81 g of 16:0, 50 g of 18:0, 295 g of *cis*9-18:1, 532 g of *cis*9,*cis*-12-18:2, 4.3 g of *cis*9,*cis*12,*cis*15-18:3 and 33 g of others FA. The cows were kept in individual stalls and had free access to water. National guidelines for the care and use of animals were followed as recommended by the Canadian Council on Animal Care (1993) and all experimental procedures were approved by the local Animal Care Committee.

2.2. Experimental procedures

Each experimental period consisted of 21 d of adaptation to the diets and 7 d of data collection and sampling. Feed intake and milk yield were measured daily throughout the experiment. On day 20, cows were fitted with harnesses and tubes allowing the total collection of feces and urine separately. From day 21 to day 27, feces were collected from a rubber mat placed behind the animals and stored in plastic containers. Daily feces were weighed and mixed thoroughly. A representative sample (20 g/kg) was taken and stored at −20 °C for subsequent freeze drying. Total daily urine was collected in stainless steel containers via Gooch tube (BF Goodrich Co., Kitchener, ON, Canada) attached to the cow with a nylon netting covered with neoprene (Spall Bowan Ltd., Guelph, ON, Canada) affixed to the vulva. Urine was acidified daily with 100 ml of 10 N H_2SO_4. A representative sample (10 g/kg) was taken and kept frozen until analysis. Samples of the four diets were taken daily during the digestibility week (days 21–28) and pooled within period for each cow. All diet samples were frozen at −20 °C for subsequent drying at 55 °C.