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Effect of a supplement containing *trans*-10,*cis*-12 conjugated linoleic acid on the performance of dairy ewes fed 2 levels of metabolizable protein and at a restricted energy intake

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ABSTRACT

Trans-10,*cis*-12 conjugated linoleic acid (CLA) inhibits milk fat synthesis in dairy ewes, but the effects under varying dietary metabolizable protein (MP) levels when energy-limited diets are fed have not been examined. The objectives of the study were to evaluate the response of lactating dairy ewes to CLA supplementation when fed diets limited in metabolizable energy (ME) and with either a low or high MP content. Twelve multiparous ewes in early lactation were randomly allocated to 1 of 4 dietary treatments: a high MP (110% of daily MP requirement) or low MP (93% of daily MP requirement) diet unsupplemented or supplemented with a lipid-encapsulated CLA to provide 2.4 g/d of *trans*-10,*cis*-12 CLA, in each of 4 periods of 25 d each in a 4 × 4 Latin square design. All diets were restricted to supply each ewe with 4.6 Mcal of ME/d (equivalent to 75% of ME requirement). Supplementation with CLA decreased milk fat percentage and yield by 33% and 24%, respectively, and increased milk, milk protein, and lactose yields by 16, 13, and 17%, respectively. Feeding the high MP diet increased the yields of milk, fat, protein, and lactose by 18, 15, 19, and 16%, respectively. Milk fat content of *trans*-10,*cis*-12 CLA (g/100 g) was 0.09 and <0.01 for the CLA-supplemented and unsupplemented ewes, respectively. Ewes supplemented with CLA had a reduced yield (mmol/d) of fatty acids of <C16, C16, and >C16, although the effect was greatest for <C16. Feeding a high MP level increased the yield of fatty acids of C16 and >C16. Plasma urea concentrations were lowest in ewes supplemented with CLA compared with those unsupplemented (6.5 vs. 7.4 mmol/L, respectively) and receiving low compared with high MP diets (5.6 vs. 8.3 mmol/L, respectively). In conclusion, dairy ewes fed energy-limited diets and supplemented with CLA repartitioned nutrients to increase yields of milk, protein, and lactose, with the response to CLA supplementation and additional MP intake being additive.

Key words: conjugated linoleic acid, metabolizable protein, milk fat depression, sheep

INTRODUCTION

Conjugated linoleic acids (**CLA**) represent different positional and geometric configurations of octadecadienoic acids containing a pair of double bonds in a conjugated configuration (Bauman and Griinari, 2003). Numerous studies have concluded that *trans*-10,*cis*-12 CLA is a potent inhibitor of milk fat synthesis in dairy cows (Bauman et al., 2008), although other isomers such as *trans*-9,*cis*-11 CLA and *cis*-10,*trans*-12 CLA have also been demonstrated to have potent milk fat depression effects in dairy cows (Saebø et al., 2005; Perfield et al., 2007). Feeding ruminally protected sources containing *trans*-10,*cis*-12 CLA has consistently been shown to reduce milk fat synthesis in dairy ewes (Lock et al., 2006; Sinclair et al., 2007, 2010). This effect occurs rapidly and in a dose-dependent manner without any detrimental effect on body organ weight or liver lipid content (Sinclair et al., 2010).

In some studies, supplementing dairy ewes with a ruminally protected source of *trans*-10,*cis*-12 CLA has been associated with increases in milk and milk protein yields (Lock et al., 2006; Husvéth et al., 2010; Sinclair et al., 2010). In contrast, Sinclair et al. (2007) reported no significant effect of *trans*-10,*cis*-12 CLA supplementation on milk performance although supplemented animals were calculated to be in a greater positive energy balance (**EBAL**). Similarly, a production response has not always been observed in dairy cows following abomasal infusion or feeding of protected sources of

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trans-10,*cis*-12 CLA. However, under situations in which energy supply was limiting, such as occurs in early lactation (Bernal-Santos et al., 2003; de Veth et al., 2005), or when dietary energy supply was restricted (de Veth et al., 2006), the energy spared by CLA-induced milk fat depression (**MFD**) appeared to be repartitioned to allow increases in the synthesis of milk protein and lactose. Supplementation with *trans*-10,*cis*-12 CLA has also been associated with an increase in milk and milk protein yield in cows that are grazing pasture (Mackle et al., 2003; Kay et al., 2006; Medeiros et al., 2010). Grazing pasture characteristically results in a limited energy intake but is usually accompanied by an excess supply of MP (Kolver and Muller, 1998). Newbold (1994) suggested that ruminants attempt to maintain an optimum MP:ME ratio and that additional dietary MP may result in a greater requirement for ME, which can be obtained by increasing dietary intake, by the use of protein as an energy source, or by mobilization of body energy reserves. A reduction in ME requirement for milk synthesis due to *trans*-10,*cis*-12 CLA-induced MFD potentially provides a fourth source of ME to the lactating animal that may be used to increase milk production. The objectives of the study were to examine the effects of *trans*-10,*cis*-12 CLA supplementation and dietary MP supply on milk fat synthesis and milk and milk protein yields in dairy ewes fed at a restricted level of ME intake. Thus, the MP and energy levels were chosen to allow comparisons that would approximate the nutritional status of ewes in early lactation or ewes fed in a pasture-based system.

MATERIALS AND METHODS

Animals, Management, and Treatments

All procedures involving animals were conducted in accordance with the UK Animals (Scientific Procedures) Act 1986. Twelve multiparous ewes were grouped immediately postlambing, housed on straw, and fed a standard ewe concentrate at the daily rate of 1.5 kg/ewe in 3 meals at 0800, 1300, and 1600 h, with grass hay (*Lolium perenne*) being offered ad libitum. Lambs were weaned from the ewes at 4 wk postpartum; the ewes were shorn, individually penned, bedded on sawdust, and milked twice daily at 0800 and 1530 h through a standard ewe milking parlor. In wk 5 of lactation the ewes were randomly allocated to 1 of 4 dietary treatments, based on their milk and constituent yield, live weight, and BCS (Russell et al., 1969) in the week before allocation.

The ewes were fed 1 of 4 complete diets containing grass hay (*Lolium perenne*), which was chopped to a mean length of 19 mm, and concentrate (0.45:0.55 DM basis; Table 1). The diets were weighed daily for each animal and offered immediately after milking at 0830 h. Feed intake for each ewe was restricted to 1.8 kg of DM/d, predicted to supply 4.6 Mcal of ME/d, which is approximately 75% of ad libitum intake (AFRC, 1993). The high MP diet was predicted to supply 110% of daily MP requirements (190 g/d), whereas the low MP diet was predicted to supply 93% of requirements (161 g/d) calculated according to AFRC (1993). These levels were chosen to supply either excess amounts of MP to resemble a pasture-based system or moderate amounts of MP for milk production to replicate ewes in early lactation, and are similar to the 117 and 88% of MP requirements used in dairy cows by de Veth et al. (2006). The diets were either unsupplemented or supplemented with a lipid-encapsulated CLA product that contained 2 CLA isomers in equal proportions, *cis*-9,*trans*-11 and *trans*-10,*cis*-12 (Lutrell, BASF SE, Ludwigshafen, Germany). The supplement (25 g/d) provided 2.4 g of *trans*-10,*cis*-12 CLA/d. The formulation and general characteristics of the lipid-encapsulated CLA product have been described previously (Lock et al., 2006), and the FA composition is given in a footnote to Table 1. The 4 treatment diets were therefore as follows: low MP − CLA, high MP − CLA, low MP + CLA, and high MP + CLA. The experimental design was a 4 × 4 Latin square with 25-d experimental periods; the first 20 d represented an adaptation period followed by a 5-d sampling period. Feed samples were collected weekly throughout the experiment, stored at −20°C, and composited before analysis. During the sampling period, milk yield was recorded daily at each milking and samples collected for analysis of fat, protein, and lactose. On the last sampling day of each period, an additional milk sample was collected and stored at −20°C for subsequent fatty acid (**FA**) analysis. On d 23 of each period, blood was sampled from the jugular vein 3 times (0730, 1130, and 1430 h) into evacuated tubes containing either lithium heparin or potassium oxalate, and the plasma was separated for subsequent analysis of urea, BHBA, and glucose. Ewe BW and BCS were measured at the start of the study and end of each period.

Chemical Analysis

Feed and milk samples were analyzed as described by Lock et al. (2006). Extraction of milk fat was performed according to the method by Hara and Radin (1978). Fatty acid methyl esters were prepared by base-catalyzed transmethylation according to Christie (1982) as modified by Chouinard et al. (1999). FA methyl esters were then injected into a gas chromatograph (Agilent 6890, Agilent Technologies UK Ltd., Berkshire, UK)