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Effects of forage type and extruded linseed supplementation on methane production and milk fatty acid composition of lactating dairy cows

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ABSTRACT

Replacing dietary grass silage (GS) with maize silage (MS) and dietary fat supplements may reduce milk concentration of specific saturated fatty acids (SFA) and can reduce methane production by dairy cows. The present study investigated the effect of feeding an extruded linseed supplement on milk fatty acid (FA) composition and methane production of lactating dairy cows, and whether basal forage type, in diets formulated for similar neutral detergent fiber and starch, altered the response to the extruded linseed supplement. Four mid-lactation Holstein-Friesian cows were fed diets as total mixed rations, containing either high proportions of MS or GS, both with or without extruded linseed supplement, in a 4 × 4 Latin square design experiment with 28-d periods. Diets contained 500 g of forage/kg of dry matter (DM) containing MS and GS in proportions (DM basis) of either 75:25 or 25:75 for high MS or high GS diets, respectively. Extruded linseed supplement (275 g/kg ether extract, DM basis) was included in treatment diets at 50 g/kg of DM. Milk yields, DM intake, milk composition, and methane production were measured at the end of each experimental period when cows were housed in respiration chambers. Whereas DM intake was higher for the MS-based diet, forage type and extruded linseed had no significant effect on milk yield, milk fat, protein, or lactose concentration, methane production, or methane per kilogram of DM intake or milk yield. Total milk fat SFA concentrations were lower with MS compared with GS-based diets (65.4 vs. 68.4 g/100 g of FA, respectively) and with extruded linseed compared with no extruded linseed (65.2 vs. 68.6 g/100 g of FA, respectively), and these effects were additive. Concentrations of total *trans* FA were higher with MS compared with GS-based diets (7.0 vs. 5.4 g/100 g of FA, respectively) and when extruded linseed was fed (6.8 vs. 5.6 g/100 g of FA, respectively). Total n-3 FA were higher when extruded linseed was fed compared with no extruded linseed (1.2 vs. 0.8 g/100 g of FA, respectively), whereas total n-6 polyunsaturated FA were higher when feeding MS compared with GS (2.5 vs. 2.1 g/100 g of FA, respectively). Feeding extruded linseed and MS both provided potentially beneficial decreases in SFA concentration of milk, and no significant interactions were found between extruded linseed supplementation and forage type. However, both MS and extruded linseed increased *trans* FA concentration in milk fat. Neither MS nor extruded linseed had significant effects on methane production or yield, but the amounts of supplemental lipid provided by extruded linseed were relatively small.
Key words: methane, forage type, linseed, milk fatty acid

INTRODUCTION

Currently, interest is considerable in developing management practices to reduce methane emissions attributable to ruminant meat and milk production, and numerous dietary strategies may be effective in reducing methane production or yield (methane per unit feed DMI). Previous studies have shown that replacing dietary ADF or NDF with starch (Mills et al., 2001), reducing NDF intake (Aguerre et al., 2011), and replacing grass silage (Reynolds et al., 2010) or alfalfa silage (Hassanat et al., 2013) with maize silage (**MS**) can reduce methane yield, but the effects are not consistent. In growing beef cattle, effects of feeding MS as a replacement for grass silage (**GS**) on methane yield varied from positive to negative over the course of the experiment (Staerfl et al., 2012). In lactating dairy cows, incremental replacement of alfalfa silage with MS had quadratic effects on methane production and yield such that methane production was higher when the silages were fed as a 50:50 mixture (Hassanat et al., 2013). Somewhat similarly, incremental replacement of GS with MS had a quadratic effect on methane production but linearly decreased methane yield in lactating dairy cows (van Gastelen et al., 2015).

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In addition to effects of forage type and composition, the reducing effects of a variety of supplemental dietary lipids on methane production, yield, or both have been demonstrated in cattle and sheep (e.g., Beauchemin et al., 2008; Grainger and Beauchemin, 2011), with the longer chain PUFA shown to be particularly effective in some studies (Blaxter and Czerkawski, 1966; Clapperton, 1974) but not in all experiments (Grainger and Beauchemin, 2011). Lipids in the diet provide ME while replacing fermentable substrates that contribute to methane synthesis in the rumen. In addition, rumen-available MUFA and PUFA provide an alternative to methane synthesis for hydrogen disposal by rumen archaea, as well as having direct effects on rumen microflora that reduce methanogenesis (Beauchemin et al., 2008). It has previously been reported that feeding supplemental linseed oil as free oil or crushed or extruded linseed reduced methane production and yield of lactating dairy cows, but DMI and milk yield were also reduced (Martin et al., 2008).

Another topic of interest is developing dairy cow feeding strategies that reduce milk fat concentrations of SFA because dairy fat is a substantial dietary source of SFA in European diets (Givens, 2008). The potential for these particular SFA to raise low-density lipoprotein cholesterol in humans has been implicated as a risk factor for cardiovascular disease (**CVD**), which is the main cause of premature death in the United Kingdom (Givens, 2008). The cow's diet is a major determinant of milk FA composition (Chilliard and Ferlay, 2004), and studies have shown that alteration of dietary forage type (Ferlay et al., 2006) and inclusion of dietary fat supplements (Kliem et al., 2009) are both means of modifying milk FA composition.

In Northern Europe, MS and GS are conserved forages commonly fed to lactating dairy cows and have been examined in various studies to investigate their differing effect on milk FA composition (Nielsen et al., 2006; Kliem et al., 2008; Samková et al., 2009; van Gastelen et al., 2015). Evidence indicates that feeding cows MS compared with GS has little effect on total SFA but can alter individual SFA concentrations (Kliem et al., 2008; van Gastelen et al., 2015). In contrast, supplemental oilseeds and plant and marine oils lower total SFA significantly, while increasing unsaturated FA (Chilliard et al., 2001; Givens et al., 2009). Increasing MS in the diet can also increase *trans* FA (Kliem et al., 2008; van Gastelen et al., 2015) through incomplete ruminal biohydrogenation of dietary unsaturated FA, although changes are of lesser magnitude than those increases reported following supplementation with dietary oils (Chilliard et al., 2001). At current intake levels, negative effects of ruminant derived *trans* on human health are equivocal (Bendsen et al., 2011), but any increases in milk fat should be minimized.

The production response to supplemental lipid is known to vary with forage type (Grainger and Beauchemin, 2011), and the objectives of the present study were to investigate the effects of dietary forage type (MS vs. GS) in diets formulated to contain similar amounts of NDF and starch and feeding an extruded linseed supplement (**ELS**) on methane production and milk FA composition in mid-lactation multiparous Holstein-Friesian dairy cows, and determine if the response to ELS was affected by forage type.

MATERIALS AND METHODS

Animals and Diets

All experimental procedures were licensed, regulated and monitored by the UK Home Office under the Animals (Scientific Procedures) Act, 1996. Four mid-lactation multiparous Holstein-Friesian dairy cows averaging (±SEM) 643 ± 40 kg of BW and 60 ± 8 DIM at the start of the study were randomly allocated to 1 of 4 experimental diets using a 4 × 4 Latin square design balanced for first order carryover effects with 28-d periods. Cows were milked twice daily at approximately 0630 and 1630 h. When not restrained for measurements, cows were housed in a cubicle yard with rubber chip-filled mattresses and wood shavings as additional bedding and were milked in a herringbone parlor. While in the cubicle yard, cows were fed individually using an electronic identification controlled pneumatic feed barrier (Insentec, Marknesse, the Netherlands) and drinking water was available ad libitum.

Experimental Design and Treatments

Throughout the study, cows were fed 1 of 4 experimental diets as a TMR (Table 1) provided for ad libitum DMI (10% refusals). Basal diets were high MS or high GS diets, with and without supplemental (50 g/kg of diet DM) ELS (containing 275 g of ether extract/kg of DM; Lintec, BOCM Pauls Ltd., Wherstead, UK), providing 4 treatments in a 2 × 2 factorial design. Diets were based on diets used in a previous study (Reynolds et al., 2010) and were formulated to be isonitrogenous and have similar NDF and starch concentrations based on preliminary analyses of available silages and expected composition of concentrates. Animals were fed twice daily receiving two-thirds of their daily allocation in the morning and the remaining one-third in the afternoon. Refused TMR was removed and weighed daily before the morning feeding.