J. Dairy Sci. 99:1–11
http://dx.doi.org/10.3168/jds.2016-10919

Effects of pregrazing herbage mass in late spring on enteric methane emissions, dry matter intake, and milk production of dairy cows

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ABSTRACT

Few studies have examined the effects of fresh forage quality on enteric methane (CH_4) emissions of dairy cows under grazing conditions. The aim of the current study was to evaluate the effects of 2 contrasting forage qualities induced by different pregrazing herbage masses in late spring on enteric CH_4 emissions and milk production of grazing dairy cows. The experiment was conducted as a crossover design with 24 lactating Holstein Friesian dairy cows randomly assigned to 1 of 2 treatments in 2 experimental periods. Each period had a duration of 3 wk (2 wk for diet adaptation and 1 wk for measurements), and the interval between them was 2 wk. Treatments consisted of 2 target pregrazing herbage masses (2,200 and 5,000 kg of dry matter (DM)/ha above 3 cm), generated by different regrowth periods, corresponding to low (LHM) and high (HHM) herbage mass treatments, respectively. Daily herbage allowance (*Lolium perenne*) for both treatments was 20 kg of DM per cow measured above 3 cm. Enteric CH_4 emissions were individually determined during the last week of each period using the sulfur hexafluoride tracer technique. Daily herbage intakes by individual cows during the CH_4 measurement weeks were estimated using the n-alkanes technique. During the CH_4 measurement weeks, milk yield and body mass were determined twice daily, whereas milk composition was determined once in the week. The LHM pasture had a higher crude protein concentration, lower neutral detergent fiber and acid detergent fiber concentrations, and higher in vitro digestibility, with a lower proportion of ryegrass pseudostems, than the HHM pasture. Cows offered the LHM pasture had greater herbage (+13%) and total DM (+12%) intakes, increased milk (+13%) and energy-corrected milk (+11%) yields, and tendencies toward higher milk protein (+4.5%) and higher milk urea nitrogen (+15%) concentrations than their counterparts offered the HHM pasture. No differences were found between treatments in total daily CH_4 production. However, the LHM treatment reduced enteric CH_4 emissions per unit of milk yield (−11%) and enteric CH_4 energy as a percentage of ingested gross energy (−9%) and tended to reduce CH_4 per unit of dry matter intake (−8.2%) and energy-corrected milk yield (−10%) compared with the HHM treatment. The results from this study suggest that a grazing management that favors better quality pasture, as was the case of the LHM pasture in late spring compared with the HHM pasture, increases milk production of grazing dairy cows and reduces enteric CH_4 emissions per unit of milk produced, constituting a viable CH_4 mitigation strategy.

Key words: herbage mass, grazing, forage quality, methane, dairy cow

INTRODUCTION

Enteric methane (CH_4) emissions from livestock have been under scrutiny due to their contribution to climate change. Methane is a potent greenhouse gas with a global warming potential that is 28 times that of CO_2 on a 100-yr time frame (Intergovernmental Panel on Climate Change, 2013). Additionally, enteric CH_4 released to the atmosphere represents feed energy that is lost, thus contributing to reduced livestock production efficiency. Ruminants lose between 2 and 12% of ingested gross energy as CH_4 (Johnson and Johnson, 1995). Improvement in forage quality, and more specifically forage digestibility, has been investigated as a means for enteric CH_4 mitigation (Martin et al., 2010; Hristov et al., 2013). Structural carbohydrates have been reported to be more methanogenic than soluble carbohydrates (Janssen, 2010). In ruminants with high feed intakes, reductions in enteric CH_4 emissions per unit of intake with increased digestibility of feeds have

Received January 20, 2016.
Accepted June 13, 2016.
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been reported (Hristov et al., 2013). Potential enteric CH_4 reductions obtained with improved forage quality would be mediated by increased concentration of soluble carbohydrates and linolenic acid (Martin et al., 2010). Greater digestibility is associated with a fermentation profile in the rumen that is unfavorable to CH_4 production. Furthermore, a more digestible feed is associated with greater intake and production, diluting maintenance energy requirements and resulting in less CH_4 per unit of animal product (Hristov et al., 2013). Much of the work for evaluating the effects of feed quality on CH_4 emissions has been carried out with diets based on concentrates and conserved forages (Yan et al., 2000; Hart et al., 2015). Research studies based on fresh forages are scarcer, and grazing studies are even more so (Lassey et al., 1997; Wims et al., 2010). In the latter, the relationship between forage quality and CH_4 emissions has been contradictory. For example, at similar intake levels, enteric CH_4 energy losses from cows grazing pasture in summer were higher than in spring, and this finding was attributed to grass maturation (Robertson and Waghorn, 2002). In contrast, Pinares-Patiño et al., (2003) reported that the proportion of gross energy intake loss as CH_4 in beef cattle did not differ with timothy pasture grazed at 4 stages of maturity.

In the dairy production systems of southern Chile, grazing management is a key factor to finding the balance between quality and quantity of fresh grazed forages. In general, greater nutrient quality and digestibility of forages is positively correlated with reduced CH_4 emissions (Hristov et al., 2013). Forage quality is in turn negatively associated with maturity. As the growing season progresses, forages go through different stages of maturity, changing from young living tissue to senescent material, with a concomitant decrease in digestibility. Digestibility changes that affect the feeding value of forages are generally associated with changes in the quantity of green leaf, mature stem, and senescent material (Holmes et al., 1992), and forage composition can be affected by grazing management. Pasture characteristics that determine forage quality, such as pregrazing herbage mass and regrowth period of pasture, affect herbage digestibility, intake and milk production (Stakelum and Dillon, 2004; McEvoy et al., 2009; Curran et al., 2010), and enteric CH_4 emissions (Wims et al., 2010). In southern Chile, forage production peaks in mid to late spring. At that time of the year, milk production relies mostly on pastures with little supplementation. Thus, changes in pasture quality are thought to be more likely to influence animal performance and methane production at this time of the year. The aim of this experiment was to evaluate the effects of pregrazing herbage mass on enteric CH_4 emissions, herbage intake, and milk production and composition of dairy cows during mid to late spring under the grazing conditions of southern Chile. We hypothesized that increasing the DM digestibility of fresh forage through grazing a low herbage mass compared with a high herbage mass pasture in late spring would result in lower enteric CH_4 emissions per unit of milk yield.

MATERIALS AND METHODS

The experiment was conducted at Instituto de Investigaciones Agropecuarias (INIA), research farm Remehue (40°31′S; 73°03′W and 65 m above mean sea level, Osorno, Chile) from October to December 2013. All procedures involving animals were performed in accordance with the requirements of the Chilean Law 20380 on Animal Protection and with the approval of the INIA Bioethics Committee.

Animals, Experimental Design, and Treatments

Twenty-four multiparous Holstein Friesian dairy cows with an initial mean body mass of 554 ± 39.3 kg were used in the study. Two weeks before the beginning of the study, all cows grazed as a single herd on a perennial ryegrass (*Lolium perenne*)–based pasture and received 2 kg (fresh basis) of a commercial concentrate daily, which was offered during milking. The cows were first blocked by pre-experimental milk yield (31.1 ± 4.0 kg/d) into 2 groups. Within each group, cows were paired based on their calving dates (113 ± 19.1 DIM) and within pairs randomly allocated to 1 of 2 dietary treatments. No initial differences existed between the groups in DIM ($P = 0.84$), milk yield ($P = 0.84$), body mass ($P = 0.17$), or age ($P = 0.79$).

A crossover design with 2 treatments and 2 feeding periods was used for the present study. Each feeding period had a 3-wk duration, which included 14 d of diet adaptation, followed by 7 d of CH_4 and other animal data collection. Treatments consisted of 2 target levels of pregrazing herbage mass: 2,200 kg of DM/ha above 3 cm (low herbage mass, **LHM**) and 5,000 kg of DM/ha above 3 cm (high herbage mass, **HHM**). Cows on both treatments were offered the same total herbage allowance of 20 kg DM above 3 cm per animal and per day, which is representative of temperate production systems in late spring. Similar herbage allowances per animal were obtained by adjusting the grazing surface of each treatment according to their pregrazing herbage mass. Between the 2 experimental periods, the cows grazed a nonexperimental pasture as a single herd for 2