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Effects of concentrate supplementation on enteric methane emissions and milk production of grazing dairy cows

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ABSTRACT

Although concentrate supplements in ruminant diets have been recognised as an effective enteric methane mitigation strategy, very few studies have examined the effects of concentrate supplementation on enteric methane emissions under grazing conditions. Twenty four multiparous Holstein Friesian cows were used in a crossover design study to investigate the effects of two concentrate feeding levels across two periods on enteric methane emissions and milk production of grazing dairy cows. Each period had a duration of four weeks (three weeks for diet adaptation and one week for measurements) and no interval in between them. Dietary treatments consisted of two concentrate feeding levels per cow (1 vs. 5 kg; as-fed basis) offered daily in equal meals during milking. Enteric methane emissions from cows grazing perennial ryegrass pasture were measured during the final week of each period using the sulphur hexafluoride tracer technique. Milk yield and liveweight were determined daily during each methane measurement period, whereas milk composition and body condition score (BCS) were determined weekly. Daily herbage intake by individual cows during methane measurement weeks was estimated using an energy requirement model and animal records and diet composition. In period 1, cows receiving 5 kg concentrate supplement were estimated to reduce herbage intake by 1.8 kg DM/d compared to cows receiving 1 kg of concentrate, whereas in period 2 cows receiving the 5 kg concentrate supplementation were estimated to reduce herbage intake by 4.4 kg DM/d, compared to cows receiving 1 kg of concentrate. In both periods, milk yield increased with increasing concentrate level, with an average milk response to concentrate supplementation of 0.68 kg milk DM/kg concentrate DM over the two periods. Concentrate feeding level had no effect on milk fat, protein or total solids contents. In period 2, lactose content increased in cows offered 5 kg/d concentrate. Increasing concentrate feeding level increased liveweight and BCS in period 1, but not in period 2. Feeding 5 kg of concentrate supplement increased enteric methane emission by 34 g/d in period 1 (323 vs. 357 g/d) and 41 g/d in period 2 (349 vs. 390 g/d) compared to 1 kg of concentrate supplement. However, enteric methane emission per unit of estimated feed intake (dry matter or gross energy) or milk output (gross or energy corrected) was not affected by level of concentrate supplementation. It was concluded that under generous grazing conditions (high allowance of good quality herbage) a moderate increase in concentrate supplementation resulted in a simultaneous increase in milk yield and enteric methane emission, so that enteric methane emission per unit of milk yield was

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unaffected. Thus, a moderate level of concentrate supplementation of dairy cows grazing pastures of high digestibility would not be an effective enteric methane mitigation strategy.

1. Introduction

Enteric methane (CH_4) is an end product of fermentation in the rumen. It represents a production inefficiency for cattle, as between 2 and 12% of the gross energy ingested through the diet is lost as CH_4 (Johnson and Johnson, 1995). Additionally, CH_4 is a potent greenhouse gas and there is growing concern for the contribution of CH_4 emissions from ruminants to global warming.

Concentrate supplements in ruminant diets have been recognised as an effective CH_4 mitigation strategy (Boadi et al., 2004; Beauchemin et al., 2008; Martin et al., 2010; Hristov et al., 2013). Evidence found with diets based on conserved forages indicates that increasing the proportion of concentrate in the diet will lower CH_4 emissions per unit of feed intake and animal product (Hristov et al., 2013). However, very few studies have examined the effects of concentrate supplementation on CH_4 emissions under grazing conditions. Lovett et al. (2005), when comparing the effects of two levels (1 vs. 6 kg, as-fed basis) of a high fibre concentrate, reported that while the daily production of CH_4 increased with increased concentrate level, so did the DMI and milk production, resulting in no effect of concentrate supplementation on CH_4 emission per unit of feed intake or milk yield. However, when CH_4 was related to fat-corrected milk yield, a decreasing tendency was identified with increased concentrate supplementation. O'Neill et al. (2012) reported higher CH_4 emissions from grazing cows supplemented with a partial mixed ration (4 kg DM) than unsupplemented cows, with no differences between treatments in CH_4 emission per unit of feed intake or milk yield. A more recent study (Jiao et al., 2014) with grazing dairy cows offered a range of concentrate feeding levels (2, 4, 6 and 8 kg as-fed basis) reported that daily CH_4 emissions were not affected, but CH_4 emissions per unit of feed intake and energy-corrected milk yield decreased with increased concentrate supplementation.

Until now, CH_4 emissions from livestock systems in southern Chile had not been determined. These systems are based on grazing and strategic supplementation with concentrates, conserved forages and fodder crops when the quantity or quality of forage decreases. We hypothesised that increasing concentrate feeding level in the diet of grazing dairy cows would decrease the proportion of dietary energy converted to CH_4 and CH_4 emissions per unit of feed intake and milk yield. The aim of the present study was to evaluate the effects of two concentrate feeding levels on CH_4 emissions and milk production of dairy cows under the grazing conditions of the south of Chile.

2. Materials and methods

The work described in this paper was conducted at Instituto de Investigaciones Agropecuarias (INIA), research farm Remehue (40°31′LS; 73°03′LW y 65 mamsl, Osorno, Chile), in accordance with the requirements of the Chilean Law 20380 on Animal Protection and with the approval of INIA Bioethics Committee.

2.1. Animals, experimental design and treatments

Twenty-four multiparous (mean parity 3.4 ± 1.3) Holstein Friesian dairy cows were used in the study. At the beginning of the study the cows averaged 70 ± 23 days in milk and 494 ± 44 kg liveweight.

The study involved a balanced crossover design (2 concentrate levels $\times$ 2 periods), with 4 wk/period, which included 21 d of adaptation to diet followed by 7 d of CH_4 and animal data collection. There was no interval between periods. Before the commencement of the study, all cows were grazing a perennial ryegrass-based sward and received 2.5 kg/d of a commercial concentrate feeding. The ingredient composition of the pelleted commercial concentrate mixture offered (12.32®, Concentrados Cisternas, Osorno, Chile) was as follows (g/kg, as-fed basis): steam-rolled corn (350), ground corn (220), rolled barley (150), wheat bran (140), dried distillers grains with solubles (50), ground beans (50) and rice bran (40). Cows were blocked into pairs according to calving date and milk yield, and within each block were allocated to 1 of 2 dietary treatments, so, that there were equal number of animals per treatment. Treatments consisted of 2 concentrate feeding levels: 1 vs. 5 kg/d of concentrate per animal (as-fed basis). The commercial concentrate used was the same as previously described and was offered in 2 equal meals by automatic parlour feeders during milking. Feed transitions were introduced gradually over 5 days during the first week of each period.

2.2. Pasture and grazing management

The study was conducted in the spring of 2012 during the months of October and November, on 2 experimental paddocks grazed successively resulting in 1 round of rotational grazing of both paddocks per period. The smaller paddock (2.15 ha) was subdivided into 4 sub-paddocks and the largest one (3.82 ha) was subdivided into 6 sub-paddocks. Each treatment group grazed adjacent sub-paddocks under strip grazing using temporary electric