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Adaptation responses in milk fat yield and methane emissions of dairy cows when wheat was included in their diet for 16 weeks

P. J. Moate,*[1] J. L. Jacobs,* M. C. Hannah,* G. L. Morris,* K. A. Beauchemin,† P. S. Alvarez Hess,‡ R. J. Eckard,‡ Z. Liu,§ S. Rochfort,§# W. J. Wales,* and S. R. O. Williams*
*Department of Economic Development, Jobs, Transport and Resources, Agriculture Research Victoria, Ellinbank, Victoria 3821, Australia
†Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada T1J 4B1
‡Faculty of Veterinary and Agricultural Science, The University of Melbourne, Parkville, Victoria 3052, Australia
§Department of Economic Development, Jobs, Transport and Resources, Agriculture Research Victoria, 5 Ring Road, Bundoora, Victoria 3083, Australia
#School of Applied Systems Biology, La Trobe University, Bundoora, Victoria 3083, Australia

ABSTRACT

Short-term studies have shown that feeding dairy cows diets containing a high proportion (>40%) of wheat may result in reduced milk fat concentration and reduced CH_4 emissions (g of CH_4/cow per d), but no long-term studies have been done on these responses. This study compared the milk production and CH_4 responses when 24 dairy cows were fed diets containing high proportions of either wheat or corn over 16 wk. Cows were assigned to 2 groups and offered a diet (CRN) containing 10.0 kg of dry matter/d of crushed corn grain, 1.8 kg of dry matter/d of canola meal, 0.2 kg of dry matter/d of minerals, and 11.0 kg of dry matter/d of chopped alfalfa hay or a similar diet (WHT) in which wheat replaced the corn. Dry matter intake and milk yields of individual cows were measured daily. Methane emissions from individual cows were measured using controlled climate respiration chambers over 2 consecutive days during each of wk 4, 10, and 16. Milk composition was measured on the 2 d when cows were in chambers during wk 4, 10, and 16. Over the 16-wk experimental period, total dry matter intake remained relatively constant and similar for the 2 dietary treatment groups. At wk 4, CH_4 emission, CH_4 yield (g of CH_4/kg of dry matter intake), milk fat yield, and milk fat concentration were substantially less in cows fed the WHT diet compared with the same metrics in cows fed the CRN diet; but these differences were not apparent at wk 10 and 16. The responses over time in these metrics were not similar in all cows. In 4 cows fed the WHT diet, CH_4 yield, milk fat concentration, and milk fat yield remained relatively constant from wk 4 to 16, whereas for 5 fed the WHT diet, their CH_4 emissions, milk fat yields, and milk fat concentrations almost doubled between wk 4 and 16. In the short term (4 wk), the inclusion of approximately 45% wheat instead of corn in the diet of cows resulted in reductions of 39% in CH_4 yield, 35% in milk fat concentration, and 40% in milk fat yield. However, these reductions did not persist to wk 10 or beyond. Our data indicate that cows do not all respond in the same way with some "adaptive" cows showing a marked increase in CH_4 yield, milk fat concentration, and milk fat yield after wk 4, whereas in other "nonadaptive" cows, these metrics were persistently inhibited to 16 wk. This research shows that short-term studies on dietary interventions to mitigate enteric CH_4 emissions may not always predict the long-term effects of such interventions.
Key words: cattle, corn, adaptation, calorimeter

INTRODUCTION

Increasing the proportion of concentrate in the diet of ruminants has been shown to reduce CH_4 yield (g/kg of DMI; Sauvant et al., 2011), but the magnitude of the effect is not the same for all grains. Beef cattle fed corn had lower CH_4 yields than cattle fed barley at the same proportion of the diet (Beauchemin and McGinn, 2005), and dairy cows fed wheat had lower CH_4 yields and intensities (g/kg of ECM) than cows fed corn or barley (Moate et al., 2016, 2017). However, the mechanisms responsible for these reductions are not clear and whether or not these effects persist in the long term has not been reported in the scientific literature.

Dietary and other interventions have been shown to have marked effects on ruminal microorganisms involved in methanogenesis (Torok et al., 2014), and in some instances, the ruminal microbial population may take many weeks to adapt to an intervention (Weimer et al., 2010). Adaptation of rumen organisms is a phenomenon that may limit the usefulness of some specific

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[1] Corresponding author: peter.moate@ecodev.vic.gov.au

dietary interventions for inhibiting CH_4 emissions. For example, although some researchers have shown dietary supplementation with monensin reduced ruminant CH_4 emissions in short-term experiments (Thornton and Owens, 1981), others have shown reductions in CH_4 may not persist more than a few weeks (Sauer et al., 1998; Omar, 2004; Guan et al., 2006). Similarly, Klop et al. (2017) recently reported that the CH_4 inhibitory effect of essential oils in dairy rations was transitory. In contrast, evidence indicates that long-term sustained inhibitory effects on methanogenesis occur in response to dietary supplementation with fat (Grainger and Beauchemin, 2011; Moate et al., 2011), tannins (Grainger et al., 2009), nitrate (van Zijderveld et al., 2011), 3-nitrooxypropanol (Hristov et al., 2015), and 2,2,2-trichloroacetamide (Trei et al., 1971).

In short-term studies of up to 5 wk, dietary supplementation with wheat has been shown to reduce CH_4 emissions by up to 50%, but in these studies milk fat concentration has been reduced by as much as 40% (Moate et al., 2012, 2014a, 2017). However, the long-term effects of dietary supplementation with wheat on CH_4 emissions, milk fat yields, and fatty acid concentrations in milk fat have not been reported in the scientific literature.

In Australia, the long-term supplementary feeding of wheat to dairy cows is a common practice (Moate et al., 2016). However, before the long-term supplementary feeding of wheat can be recommended as an on-farm feeding strategy to mitigate CH_4 emissions, and before the putative CH_4 inhibitory effects of wheat feeding can be taken into account in the Australian National Inventory of Greenhouse Gases, the long-term effects of dietary supplementation with wheat on CH_4 emissions must be quantified.

The objective of this work was to compare, over 16 wk, the effects of supplementary feeding of diets containing either corn or wheat on milk production, milk fat yield, fatty acid composition of milk fat, and CH_4 emissions.

We hypothesized the following:

(1) Cows fed a diet containing corn would initially produce milk with higher milk fat concentration and yield, and emit more CH_4 and have a greater CH_4 yield than cows fed a similar diet containing wheat.
(2) Mean milk fat concentrations and fatty acid profiles in the milk from cows fed corn- or wheat-supplemented diets would not change between wk 4 and 16 of the experiment.
(3) The relative difference in CH_4 yield between the cows fed corn or wheat grain would not diminish between wk 4 and 16 and that the absolute CH_4 yields of cows within each treatment would not differ between wk 4 and 16.
(4) Methane yield of cows would be correlated with the daily nadir in pH of ruminal fluid.

MATERIALS AND METHODS

Cows, Experimental Design, and Diets

Twenty-four multiparous, lactating Holstein-Friesian cows (including 12 ruminally fistulated; 110 mm internal diameter, Rumen Cannula, www.rumencannula.com) were used in this experiment. At the beginning of the experiment, the cows were producing 36.0 ± 5.42 kg of milk/d (mean ± SD) and had BW of 549 ± 36.0 kg, were 29 ± 5.8 DIM, were 5.3 ± 2.15 yr of age and had, on average, 3.3 ± 2.14 lactations. Cows were cared for according to the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (NHMRC, 2013). Animal use was approved by the Animal Ethics Committee of the Department of Economic Development Jobs Transport and Resources–Victoria.

The experiment design was a 2 × 2 factorial (fistulate × diet) treatment structure with 6 cows per treatment. The design employed a 4-row × 6-column blocking structure, the rows corresponding to 4 cohort blocks defined according to calving date, block 1 being the 6 earliest calving cows, up to block 4, the 6 latest calving cows, and the 6 columns corresponded to 6 respiration chambers. This design was chosen to allow the cohort blocks of 6 cows to be sequenced through the chambers in calving date order. The design was generated and randomized, using CycDesigN software (VSN International, Hemel Hempstead, UK), such that each of the 4 treatments was replicated 6 times, represented once in each chamber, once or twice in each block, and such that fistulation, rather than diet, was partially confounded with block. It was necessary to swap 2 cows between adjacent calving date blocks to ensure the specified number of fistulated cows occurred in each block.

The diets were the (1) corn diet (**CRN**) of 10.0 kg of DM/d of crushed corn grain, 1.8 kg of DM/d of canola meal, 0.2 kg of DM/d of minerals, and 11.0 kg of DM/d of chopped alfalfa hay; and (2) wheat diet (**WHT**), which was the same as the CRN diet, except that crushed wheat grain substituted for the crushed corn grain. The chemical compositions of the feeds and mineral mix are shown in Table 1.

Logistics

Throughout this experiment, the concentrate portion of the diet was offered to the cows separately from