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Wheat is more potent than corn or barley for dietary mitigation of enteric methane emissions from dairy cows

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ABSTRACT

Wheat is the most common concentrate fed to dairy cows in Australia, but few studies have examined the effects of wheat feeding on enteric methane emissions, and no studies have compared the relative potencies of wheat, corn, and barley for their effects on enteric methane production. In this 35-d experiment, 32 Holstein dairy cows were offered 1 of 4 diets: a corn diet (CRN) of 10.0 kg of DM/d of single-rolled 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; a wheat diet (WHT) similar to the CRN diet but with the corn replaced by single-rolled wheat; a barley diet (SRB) similar to the CRN diet but with the corn replaced by single-rolled barley; and a barley diet (DRB) similar to the CRN diet but with the corn replaced by double-rolled barley. Individual cow feed intakes, milk yields, and milk compositions were measured daily but reported for the last 5 d of the experiment. During the last 5 d of the experiment, individual cow methane emissions were measured using the SF_6 tracer technique for all cows, and ruminal fluid pH was continuously measured by intraruminal sensors for 3 cows in each treatment group. The average dry matter intake of cows offered the CRN, WHT, SRB, and DRB diets was 22.2, 21.1, 22.6, and 22.6 kg/d. The mean energy-corrected milk of cows fed the WHT diet was less than that of cows fed the other diets. This occurred because the milk fat percentage of cows fed the WHT diet was significantly less than that of cows fed the other diets. The mean methane emissions and methane yields of cows fed the WHT diet were also significantly less than those of cows fed the other diets. Indeed, the CRN, SRB, and DRB diets were associated with 49, 73, and 78% greater methane emissions, respectively, compared with the emissions from the WHT diet. Methane yield was found to be most strongly related to the minimum daily ruminal fluid pH. This study showed that although the inclusion of wheat in the diet of dairy cows could be an effective strategy for substantially reducing their methane emissions, it also reduced their milk fat percentage and production of milk fat and energy-corrected milk.
Key words: ruminal fluid, pH, cattle, methane, starch

INTRODUCTION

Methane is a potent greenhouse gas, and there is ongoing interest in reducing methane emissions from dairy cows (Moate et al., 2011; O'Mara, 2011). It is well known that feeding ruminants diets containing a high concentration of starch can improve production and reduce their enteric methane emissions, but most published studies have used diets fortified with either corn grain or barley grain (Grainger and Beauchemin, 2011; Sauvant et al., 2011). Many studies have used concentrate mixtures containing corn grain, barley grain, wheat grain, soybean meal, sugar beet pulp, citrus pulp, maize gluten, sunflower meal, calcium soaps of fatty acids, and other ingredients, and the concentrates may have been pelletized or included in a TMR (Kebreab et al., 2003). Wheat is a cereal grain commonly included in the diet of dairy cows, but few studies have examined the effects of wheat feeding on enteric methane emissions from dairy cows (Moate et al., 2016). Substituting wheat into the diet of lactating dairy cows in place of forage reduced methane emissions and methane yield (g/kg of DM) with no negative effect on milk volume, although high levels (i.e., >40% of DMI) of wheat feeding may depress milk fat concentration (Williams et al., 2013; Moate et al., 2014a).

Corn, barley, and wheat generally contain high proportions of starch, and in sacco studies indicate that different methane yields from different grain diets are related to the different rates of degradation of either DM or starch in each grain (Herrera-Saldana et al., 1990). Few in sacco studies have compared the DM

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and starch degradation characteristics of corn, barley, and wheat, but the general consensus is that the DM and starch in wheat is more quickly degraded than the DM and starch in barley (Herrera-Saldana et al., 1990; McDonnell et al., 2017), whereas the DM and starch in barley is more quickly degraded than the DM and starch in corn (Granzin, 2004; Greenwood et al., 2014).

As far as we can ascertain, no studies have directly compared the relative potencies of wheat, corn, and barley for their effects on enteric methane production in dairy cows. However, Beauchemin and McGinn (2005) fed finishing beef cattle diets containing 81.4% of either dry-rolled corn or steam-rolled barley and reported different methane yields of 9.2 and 13.1 g of CH_4/kg of DMI for the respective diets. Thus, the type of grain fed has the potential to substantially influence methane emissions. Based solely on assumed differences in the relative rates of starch degradability, one might expect that the barley diet would have been associated with a lower methane yield than the corn diet. However, in the experiment of Beauchemin and McGinn (2005), the barley had a higher NDF concentration than the corn, and the ruminal fluid pH was greater in the barley-fed animals.

The mechanism whereby the DM and starch degradability rates influence methane yields is not well understood but is possibly related to differences in specific features of the daily pH pattern in ruminal fluid, which results when cows are fed cereal grains that differ in their rate of ruminal starch degradability. Low pH has been reported to reduce methanogenesis in vitro (Van Kessel and Russell, 1996; Russell, 1998); this effect has also been observed in vivo where the methane emission from beef heifers was related to their mean ruminal pH (Doreau et al., 2011; Hünerberg et al., 2015). In contrast, Moate et al. (2012) found methane reductions were reflected in greater duration of pH below 6 and greater area below pH 6 but not in mean ruminal pH.

In addition, increasing the degree of processing (i.e., smaller particle sizes) of cereal grains can increase the rate of ruminal degradation of the grain and decrease ruminal pH (Herrera-Saldana et al., 1990; Yang et al., 2001). Thus, it is possible that differences in degree of processing between the grain types rather than differences between the grains per se might have been responsible for differences in methane emissions in some studies that have compared different types of grains for their effects on methane emissions.

The objective of this experiment was to determine the effect of feeding wheat, corn, and barley on methane emissions from lactating dairy cows and to determine whether any observed effect is related to degree of processing of barley, grain type, or ruminal fluid pH characteristics. We hypothesized (1) that the type of grain would have no effect on milk production or ECM yield; (2) that the type of grain would affect methane emissions, yield, and intensity; (3) that the degree of processing (dry rolling) of barley grain would affect the methane yield; and (4) that methane yield across grain types would be negatively related to their relative rates of degradation of DM and starch and would correlate with specific features of the daily pattern in ruminal fluid pH.

MATERIALS AND METHODS

Cows, Diets, and Management

Thirty-two lactating multiparous Holstein-Friesian cows (including 12 rumen-cannulated cows) producing 32.3 ± 4.38 kg of milk/d (mean ± SD) with a BW of 537 ± 70.9 kg and that were 71 ± 8.7 DIM were allocated to 4 groups balanced for mean milk yield, BW, age, and DIM according to the method of Baird (1994). Each group of 8 cows (including 3 rumen-cannulated cows) was then randomly allocated to 1 of 4 dietary treatments in which cows were scheduled to individually receive the following: (1) a corn diet (**CRN**) of 10.0 kg of DM/d of single-rolled corn, 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; (2) a wheat diet (**WHT**) similar to the CRN diet but with the corn replaced by single-rolled wheat; (3) a barley diet (**SRB**) similar to the CRN diet but with the corn replaced by single-rolled barley; or (4) a double-rolled barley diet (**DRB**) similar to the CRN diet but with the corn replaced by double-rolled barley. The corn, wheat, and single-rolled barley had been passed once through a roller mill, but the double-rolled barley had been passed twice through the same roller mill to further reduce particle size. The amount of DM offered to each cow in all treatments was the same.

All cows were offered a common diet of 6 kg of DM/d of crushed wheat and 16 kg of DM/d of chopped alfalfa hay during the covariate period (d 1–7), then gradually transitioned to their experimental diets from d 8 to 14. From d 15 to 35, each cow was offered her allocated experimental diet. Days 15 to 28 served as an adaptation period to allow the rumen to adapt to the experimental diets, whereas d 29 to 35 were used as the experiment measurement period. 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.