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Grape marc reduces methane emissions when fed to dairy cows

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ABSTRACT

Grape marc (the skins, seeds, stalk, and stems remaining after grapes have been pressed to make wine) is currently a by-product used as a feed supplement by the dairy and beef industries. Grape marc contains condensed tannins and has high concentrations of crude fat; both these substances can reduce enteric methane (CH_4) production when fed to ruminants. This experiment examined the effects of dietary supplementation with either dried, pelleted grape marc or ensiled grape marc on yield and composition of milk, enteric CH_4 emissions, and ruminal microbiota in dairy cows. Thirty-two Holstein dairy cows in late lactation were offered 1 of 3 diets: a control (CON) diet; a diet containing dried, pelleted grape marc (DGM); and a diet containing ensiled grape marc (EGM). The diet offered to cows in the CON group contained 14.0 kg of alfalfa hay dry matter (DM)/d and 4.3 kg of concentrate mix DM/d. Diets offered to cows in the DGM and EGM groups contained 9.0 kg of alfalfa hay DM/d, 4.3 kg of concentrate mix DM/d, and 5.0 kg of dried or ensiled grape marc DM/d, respectively. These diets were offered individually to cows for 18 d. Individual cow feed intake and milk yield were measured daily and milk composition measured on 4 d/wk. Individual cow CH_4 emissions were measured by the SF_6 tracer technique on 2 d at the end of the experiment. Ruminal bacterial, archaeal, fungal, and protozoan communities were quantified on the last day of the experiment. Cows offered the CON, DGM, and EGM diets, ate 95, 98, and 96%, respectively, of the DM offered. The mean milk yield of cows fed the EGM diet was 12.8 kg/cow per day and was less than that of cows fed either the CON diet (14.6 kg/cow per day) or the DGM diet (15.4 kg/cow per day). Feeding DGM and EGM diets was associated with decreased milk fat yields, lower concentrations of saturated fatty acids, and enhanced concentrations of mono- and polyunsaturated fatty acids, in particular *cis*-9,*trans*-11 linoleic acid. The mean CH_4 emissions were 470, 375, and 389 g of CH_4/cow per day for cows fed the CON, DGM, and EGM diets, respectively. Methane yields were 26.1, 20.2, and 21.5 g of CH_4/kg of DMI for cows fed the CON, DGM, and EGM diets, respectively. The ruminal bacterial and archaeal communities were altered by dietary supplementation with grape marc, but ruminal fungal and protozoan communities were not. Decreases of approximately 20% in CH_4 emissions and CH_4 yield indicate that feeding DGM and EGM could play a role in CH_4 abatement.
Key words: fat, tannin, fatty acid, microbial profiling

INTRODUCTION

Methane (CH_4) is a potent greenhouse gas (IPCC, 2007). Enteric CH_4 emissions from ruminants amount to approximately 80 million tonnes annually and account for approximately 28% of global anthropomorphic CH_4 emissions (Beauchemin et al., 2008). Interest is growing in developing practical nutritional strategies for ruminants that will reduce these emissions.

One strategy that can reduce CH_4 emissions is the addition of fat to the diet of ruminants (Beauchemin et al., 2008; Moate et al., 2011). Another effective strategy for reducing enteric CH_4 emissions from ruminants involves including condensed tannins (**CT**) in their diet (Waghorn et al., 2002; Grainger et al., 2009). Grape marc is the skins, seeds, and stems that remain after grapes (*Vitis vinifera*) have been pressed to make wine. Grape marc contains high concentrations of both fat and tannin (Spanghero et al., 2009). In one experiment, when cows were fed 20% of their dietary DMI as ensiled grape marc (**EGM**), no negative effects were observed on their DMI, milk yields or milk composition (Belibasakis et al., 1996). In vitro studies have shown that tannin extracted from grape seed can reduce CH_4 production (Pellikaan et al., 2011), but little information is available concerning the nutritional value of grape

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marc as a ruminant feed and its potential to reduce CH_4 emissions from ruminants. Theoretically, the fats and tannins in grape marc may inhibit CH_4 emissions if fed to ruminants. However, how the fats and tannins in grape marc interact with the ruminal microbiota is not known.

In Australia, 2 commercially available forms of grape marc exist: dried grape marc (**DGM**) and EGM. Grape marc is usually first steam distilled for up to 15 min at approximately 94°C to extract ethanol, and the residue from this distillation (spent grape marc) is then ensiled for a period of at least 1 mo to produce EGM. Dry grape marc is made from the spent grape marc, which is stockpiled for several months before making a dry meal powder. Drying occurs as a continuous process for approximately 20 min, in a gas-fired rotary drum heated to approximately 120°C. The resulting dry meal is ground and then steam-pelleted at 85°C. (B. Mengersen, Tarac Technologies Pty. Ltd., Nuriootpa, Australia, personal communication).

In Australia, dairying is mostly pasture based, with many cows grazing all year. Cows calve in the spring when pasture is abundant and of high quality. However, during the summer, high temperatures and lack of rain generally result in low pasture growth rates and reduced milk yields. By February (late summer) and March (early autumn) all cows in the herds with seasonally concentrated calving pattern are in late lactation and poor-quality pasture and low pasture availability exacerbates low milk yields. At this time of the year, farmers may feed their cows feed supplements of concentrates (mainly wheat), but a fiber source such as hay, pasture silage, or grape marc is also required. During times of drought (1999–2009) and during most summers, purchased hay becomes very expensive. Thus, despite the low nutritional quality of grape marc (Belibasakis et al., 1996), it has potential to be incorporated into dairy cow rations because it has a high concentration of fiber, and it is currently a waste product with low cost compared with the alternative of expensive purchased hay. This experiment was designed to mimic the feeds, feeding practices, and conditions on many dairy farms in late summer in southern Australia and to examine the effect on dairy cow production and CH_4 emissions when grape marc is incorporated into such diets

The objective of this research was to compare the effects on CH_4 emissions, milk yield, milk composition, and ruminal microbiota resulting from feeding either a control diet or diets containing DGM or EGM to dairy cows in late lactation. We hypothesized that feeding DGM or EGM instead of alfalfa hay to dairy cows (1) would not influence yields of milk, milk fat, or milk protein; and (2) the 2 types of grape marc would inhibit CH_4 emissions from dairy cows to an equal extent.

MATERIALS AND METHODS

The experiment was conducted at the Department of Environment and Primary Industries, Ellinbank Centre, Victoria, Australia (**DEPI** Ellinbank; 38°14′S, 145°56′E) in accordance with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2004 (NHMRC, 2004). Cow use was approved by the Animal Ethics Committee of the Department of Environment and Primary Industries (Victoria).

Cows and Diets

Thirty-two lactating, multiparous Holstein-Friesian cows, each producing 16.3 ± 1.83 L of milk/d (average ± SD) with 582 ± 54.2 kg of BW and 203 ± 72.8 DIM were allocated to 3 groups balanced for mean milk yield, BW, and yields of fat and protein according to the method of Baird (1994). Each group was then randomly allocated to 1 of 3 dietary treatments: (1) A control (**CON**) diet in which cows were individually offered 14.0 kg of alfalfa hay DM/d and 4.3 kg of concentrate mix DM/d; (2) a DGM diet in which cows were individually offered 9.0 kg of alfalfa hay DM/d, 5.0 kg of DGM DM/d, and 4.3 kg of concentrate mix DM/d; or (3) an EGM diet in which cows were individually offered 9.0 kg of alfalfa hay DM/d, 5.0 kg of EGM DM/d, and 4.3 kg of concentrate mix DM/d. The EGM used in this experiment had been ensiled for 11 mo. The concentrate mix contained 93.0% crushed wheat, 4.7% dried molasses, and 2.3% mineral mix (DM basis).

The CON treatment group had 12 cows assigned to it, whereas the DGM and EGM treatment groups each originally had 10 cows. However, 1 cow in the EGM treatment group contracted mastitis and was removed from the experiment. On d 1 to 16 of the experiment, all cows received the CON treatment so that covariate measures could be obtained. From d 17 to 19, cows allocated to the DGM and EGM treatments transitioned onto their dietary treatment, with the CON cows remaining on their CON diet. All cows then were offered their full allocated treatment diet until d 37; that is, for 18 d duration.

Feeding and Measurements

Cows were fed in individual feed stalls within a well-ventilated animal house (Williams et al., 2011). Cows were offered their dietary treatments in 2 equal portions between 0730 and 1130 h, and 1530 and 1930 h each day. Cows were offered the concentrate mix and grape marc between 0730 and 0900 h in the morning and between 1530 and 1700 h in the afternoon. The alfalfa hay was offered to the cows between 0900 and