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Influence of feeding supplements of almond hulls and ensiled citrus pulp on the milk production, milk composition, and methane emissions of dairy cows

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ABSTRACT

Almond hulls and citrus pulp have been fed to dairy cows with variable responses for milk production, but no information exists on their effect on enteric methane emissions. This experiment examined the effects of dietary supplementation with either almond hulls or ensiled citrus pulp on the milk yield, milk composition, and enteric methane emissions of dairy cows. Thirty-two Holstein dairy cows in mid lactation were offered 1 of 3 diets over a 28-d experiment. Twelve cows received a control (CON) diet, 10 cows a diet containing almond hulls (ALH), and 10 cows a diet containing ensiled citrus pulp (CIT). All cows were offered 6.0 kg of dry matter (DM)/d of crushed corn, 2.0 kg of DM/d of cold-pressed canola, and 0.2 kg of DM/d of a mineral mix. In addition, cows fed the CON diet were offered 14.5 kg of DM/d of alfalfa cubes; cows fed the ALH diet were offered 10.5 kg of DM/d of alfalfa cubes and 4.0 kg of DM/d of almond hulls; and cows on the CIT diet were offered 11.5 kg of DM/d of alfalfa cubes and 3.0 kg of DM/d of ensiled citrus pulp. Milk yield was measured daily and milk composition was measured on 4 d of each week. Individual cow methane emissions were measured by a sulfur hexafluoride tracer technique on d 24 to 28 of the experiment. The mean milk yield of cows fed the CON diet (27.4 kg/d) was greater than the mean milk yield of cows fed the ALH diet (24.6 kg/cow per day), whereas the mean milk yield of cows fed the CIT diet (26.2 kg/cow per day) was not different from the mean milk yield from cows fed the other 2 diets. Dietary treatment did not influence the concentrations of milk fat, protein, and lactose or fat yields, but the mean protein yield from cows fed the CON diet (0.87 kg/d) was greater than that from cows fed the ALH diet (0.78 kg/d) but not different to those fed the CIT diet (0.85 kg/d). In general, we found no differences in the proportion of individual fatty acids in milk. The mean pH of ruminal fluid from cows offered the CON diet was not different to the pH in the ruminal fluids of cows offered the ALH or the CIT diets. The mean methane emissions (g/d) and yields (g/kg of DMI) were not influenced by dietary treatment. These findings indicate that, although almond hulls and ensiled citrus pulp can be used as a low-cost feed supplement, almond hulls did negatively affect milk production and neither inhibited enteric methane emissions.
Key words: methane yield, cattle, sulfur hexafluoride

INTRODUCTION

Horticultural by-products can be used as alternative feed supplements for ruminants, especially in times of drought when pasture is not present and traditional feeds, such as pasture hay or alfalfa hay, are scarce or expensive. Almond hulls consist of the outer covering of the almond, but do not include the hard shell. They have been included in the diets of dairy cows (Aguilar et al., 1984; Singer et al., 2008), sheep (Alibés et al., 1983), and goats (Reed and Brown, 1988; Can et al., 2007). Previously observed reductions in DMI when almond hulls have been fed may be due to a shortage of rumen-degradable protein in the diet (Alibés et al., 1983), which could be why a reduction in blood urea concentration has also been reported (Can et al., 2007). However, when almond-hull diets were fortified with nitrogen by the addition of urea, there was no difference in dairy cow performance (Aguilar et al., 1984).

Citrus pulp, consisting of the skin, pulp, and seed residues remaining when citrus fruits are processed for juice, has been fed to dairy cows (e.g.: Belibasakis and Tsirgogianni, 1996; Leiva et al., 2000). Most research has reported no significant difference in milk yield or milk composition between cows fed citrus pulp and a comparative diet (e.g.: Leiva et al., 2000; Gehman et al., 2006). However, several reports have shown cows

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fed citrus pulp produce milk with higher fat concentration compared with cows fed other diets (e.g., van Horn et al., 1975; Belibasakis and Tsirgogianni, 1996). This response in milk fat concentration to the feeding of citrus pulp appears to be related to the concentration of citrus pulp in the diet. In sheep, milk fat concentration was observed to increase with increasing proportions (0 to 20%) of citrus pulp in the diet, but declined when citrus pulp was fed at 30% of the diet (Jaramillo et al., 2009).

In addition to their value as dietary supplements, we speculate that both almond hulls and citrus pulp may reduce methane emissions from dairy cows. Almond hulls have been shown to inhibit methane production in vitro, with phenolics, triterpenoids, and antibacterial compounds being identified as possible causes (Durmic et al., 2014). Citrus pulp contains limonene, an essential oil, which has been shown in vitro to have antimethanogenic properties (Kamalak et al., 2011). Thus, we expect that feeding almond hulls and citrus pulp to dairy cows may decrease their methane emissions, with no effect on their milk production or on concentrations of milk fat and milk protein. However, methane yield has been correlated with the fatty acid profile of milk (e.g., Dijkstra et al., 2011), and the fatty acid profile of milk influences the melting point of the milk fat (Jensen and Patton, 2000), which in turn influences the suitability of the milk for the manufacture of dairy products (Hillbrick and Augustin, 2002). If the feeding of almond hulls or citrus pulp does indeed change the amount of methane produced, then we would expect concomitant changes in fatty acid profiles and the melting point of the milk fat.

The aim of our research was to determine the effects of feeding diets containing almond hulls or ensiled citrus pulp to dairy cows on their milk production, milk composition, and methane emissions. We hypothesized that when almond hulls or ensiled citrus pulp replaced alfalfa cubes in the diet of dairy cows we would find (1) no effects on milk production and concentrations of total milk fat and milk protein, (2) a reduction in methane emissions and (3) a change in the fatty acid profile of milk with a commensurate change in the melting point of milk fat.

MATERIALS AND METHODS

The experiment was conducted at the Department of Economic Development Jobs Transport and Resources, Ellinbank Centre, Victoria, Australia (38°14′ S, 145°56′ E) and was conducted in accordance with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (NHMRC, 2004). Animal use was approved by the Animal Ethics Committee of the Department of Economic Development Jobs Transport and Resources, Victoria.

Experiment Design and Management

The experiment used 32 lactating, multiparous Holstein-Friesian cows producing 25.2 ± 2.00 kg milk/d (mean ± SD), with 614 ± 57.6 kg of BW and 147 ± 18.2 DIM. We used 3 dietary treatments. First, a control diet (**CON**) in which cows were individually offered 6.0 kg of DM/d of crushed corn grain, 2.0 kg of DM/d of cold-pressed canola meal, 0.2 kg of DM/d of a vitamin and mineral mix (calcium 134 mg/g, magnesium 110 mg/g, phosphorus 60 mg/g, zinc 6.4 mg/g, copper 1.2 mg/g, iodine 80 μg/g, cobalt 100 μg/g, selenium 24 μg/g, vitamin A 51 IU/g, vitamin D_3 24 IU/g, and vitamin E 0.8 IU/g), and 14.5 kg of DM/d of alfalfa cubes. The second diet was an almond hull diet (**ALH**) in which cows were individually offered 6.0 kg of DM/d of crushed corn grain, 2.0 kg of DM/d of cold-pressed canola meal, 0.2 kg of DM/d of minerals, 4.0 kg of DM/d of almond hulls, and 10.5 kg of DM/d of alfalfa cubes. The third diet was a citrus pulp diet (**CIT**) in which cows were individually offered 6.0 kg of DM/d of crushed corn grain, 2.0 kg of DM/d of cold-pressed canola meal, 0.2 kg of DM/d of minerals, 3.0 kg of DM/d of ensiled citrus pulp, and 11.5 kg of DM/d of alfalfa cubes. Individual servings of almond hulls were soaked in 1.8 L of water for 12 h to increase palatability. The citrus pulp was composed of the skins and pith residue from oranges that had been used to produce orange juice. Given the aim of the investigation was to determine the effect of substituting almond hulls or citrus pulp for alfalfa, we made no attempt to balance for energy or nitrogen.

The CON treatment was randomly assigned to 12 cows, whereas the ALH and CIT treatments were each randomly assigned to 10 cows, subject to the 3 treatment groups being balanced for mean milk yield, BW, and yields of fat and protein according to the method of Baird (1994). Cows were transitioned to their diets on d 1 to 7, and then all cows were on their assigned diet for the remaining 21 d of the experiment.

Feeds

Diets were offered to cows in 2 equal portions, one portion from 0700 to 1100 h and the other from 1530 to 1930 h each day. Feeds were offered in a specific sequence. Quantities of corn grain, canola, and minerals offered to individual cows were weighed then mixed by hand in a plastic tub before being offered in the milking parlor during milking. Cows were given up to 30 min to consume their concentrate mix. Refusals