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Incorporating mixed rations and formulated grain mixes into the diet of grazing cows: Effects on milk composition and coagulation properties, and the yield and quality of Cheddar cheese

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ABSTRACT

Effects of different strategies for feeding supplements to grazing dairy cows on the composition and coagulation properties of milk and the subsequent yield and quality of Cheddar cheese were measured. The experiment used milk from 72 Holstein-Friesian cows, averaging 45 d in milk, fed according to 1 of 3 feeding strategies: (1) cows grazed a restricted allowance of perennial ryegrass pasture [approximately 14 kg of dry matter (DM)/cow per day, to ground level] supplemented with milled wheat grain fed in the milking parlor and alfalfa hay offered in the paddock (control); (2) same pasture and allowance as control, supplemented with a formulated grain mix containing wheat grain, corn grain, and canola meal fed in the parlor and alfalfa hay fed in the paddock (FGM); or (3) same pasture and allowance as control, supplemented with a partial mixed ration comprising the same formulated grain mix but mixed with alfalfa hay and presented on a feed pad after each milking (PMR). For all strategies, supplements provided the same metabolizable energy and grain:forage ratio (78:22, DM basis). Within each feeding strategy, milk was sampled from cows receiving either 8 or 16 kg (DM) of supplement/cow per day. There were 2 replicated groups of 6 cows per supplement amount per dietary strategy; approximately 250 L of milk was sampled from each for analyses of composition and coagulation properties and the manufacture of Cheddar cheese. The experiment had a 14-d adaptation period and a 14-d measurement period. For cows fed according to the control strategy, those fed 16 kg/cow per day produced milk with lower concentrations of milk fat than cows fed 8 kg/cow per day. This effect was not observed for cows fed according to the FGM and PMR strategies. Milk from cows fed 16 kg of DM/cow per day according to the control strategy yielded less Cheddar cheese than milk from cows fed according to the PMR strategy, with cheese yields from FGM cows being intermediate. Amount of supplement offered had minor effects on percentages of some fatty acids. We observed few other effects of feeding strategy on milk composition, types of milk protein, milk coagulation properties, or the composition and quality of the resultant Cheddar cheese. These data show that, compared with the traditional control strategy, feeding PMR or FGM may increase milk fat concentration and the subsequent yield of Cheddar cheese without compromising cheese composition or quality.

Key words: ration, grazing cow, milk fat, milk protein, Cheddar cheese

INTRODUCTION

Grazed pasture and conserved homegrown forage have traditionally been major sources of nutrients for dairy cattle in many parts of the world because of their low cost (Doyle et al., 2000; Bargo et al., 2003; Doyle and Stockdale, 2011). Pasture is commonly supplemented with cereal grain or pelleted concentrates fed in the parlor at milking times to allow increased stocking rates and milk production per cow. In southeast Australia in recent years, the trend has been for heavier reliance on bought-in forage and concentrates to meet the nutritional requirements of the milking herd, due largely to below-average rainfall and reduced pasture production (Wales et al., 2013).

When grain supplements are fed in the parlor, milk production often increases (Walker et al., 2001; Leddin et al., 2009) but the amount of extra milk produced per kilogram of grain usually decreases as the amount of grain increases (Stockdale et al., 1987; Kellaway and Harrington, 2004). These diminishing returns are probably partly due to increases in the variation of ruminal fluid pH and the time per day that the pH is below 6.0 (Wales and Doyle, 2003). This can be associated

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with impaired rumen fermentation and NDF digestion (Mould et al., 1983; Dixon and Stockdale, 1999; Wales et al., 2000) and reduced DMI and milk production when high amounts of grain are ingested over a short period (Auldist et al., 2013, 2014, 2016).

Recent research has shown that a more efficient way of feeding high amounts of supplements to grazing dairy cows may be to feed them as a mixed ration on a feed pad, in between bouts of grazing (Bargo et al., 2002). Under some circumstances, supplementing the diet of grazing dairy cows with a so-called partial mixed ration (**PMR**) containing corn (Auldist et al., 2013) and canola meal (Auldist et al., 2014; Golder et al., 2014) has resulted in greater production of ECM than obtained by feeding equivalent amounts of energy via the traditional systems detailed above. These responses were associated with higher and less variable ruminal pH and increased DMI of both pasture and supplement. Further, a companion paper to the current experiment (Auldist et al., 2016), showed that most of the milk production benefits of PMR feeding strategies could be obtained by feeding the grain components of the PMR (i.e., cereal grain, corn grain, and canola meal) in the parlor using the existing automated feeding infrastructure. Such feeding strategies would be relevant to a larger proportion of producers in the pasture-based dairying regions of Australia, the majority of whom do not own mixer wagons or feed pads.

In these experiments (Auldist et al., 2013, 2014, 2016), the ECM production responses were associated with changes in the concentrations of milk fat and protein. Because concentrations of fat and protein in milk, and their ratios relative to one another, are known to influence milk coagulation properties and the yield and quality of dairy products (Guinee et al., 1997, 2006, 2007), information is needed about the effects of these alternative feeding strategies on the suitability of milk for manufacturing before they can be widely recommended to dairy producers. The Australian dairy industry is heavily reliant on exporting high-quality dairy products, especially Cheddar cheese. Thus, the current experiment had the aim of determining the effects of 3 different strategies for feeding supplements to grazing dairy cows on the composition and coagulation properties of milk and the subsequent yield and quality of Cheddar cheese. The hypotheses tested were that (1) cows fed large amounts of corn and canola-based supplements would produce milk that yielded more Cheddar cheese than cows fed similar amounts of ME as wheat grain in the parlor and lucerne hay in the paddock; and (2) supplementary feeding strategy would not affect the composition and quality of the cheese.

MATERIALS AND METHODS

Experiment Details

The experiment was undertaken at the Department of Economic Development, Jobs, Transport and Resources (DEDJTR), Ellinbank, Victoria, Australia (38°14′S, 145°56′E). All procedures were conducted according to the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and were approved by the DEDJTR Agricultural Research and Extension Animal Ethics Committee.

The feeding experiment was conducted in spring using 144 multiparous, seasonally calving Holstein-Friesian dairy cows and has been described in full by Auldist et al. (2016). All cows had calved in late winter and early spring, were between 4 and 7 yr old and an average of 45 DIM, and were milked twice daily at approximately 0700 and 1500 h. The experiment comprised a 14-d adjustment period followed by a 14-d measurement period during which milk and cheese measurements were made.

Supplement Feeding Strategies

Cows were allocated into 6 groups of 24 cows balanced for DIM, age, BW, and production of milk, milk protein, and milk fat in the previous lactation. One of the following 3 feeding strategies was then randomly assigned to 2 of the 6 groups (Table 1):

(1) Control: Cows grazed perennial ryegrass (*Lolium perenne* L.) pasture supplemented with milled wheat grain fed twice daily in the milking parlor and alfalfa hay provided in the paddock. The ratio of grain to hay was 78:22 (DM basis).
(2) Formulated grain mix (**FGM**): Cows grazed perennial ryegrass pasture at the same allowance as the control cows. They were also fed a FGM comprising milled wheat grain, crushed corn grain and canola meal in the parlor during milking, and alfalfa hay in the paddock. The composition of the total supplement (DM basis) was milled wheat grain (38%), crushed corned grain (18%), canola meal (22%), and alfalfa hay (22%). The ration in this treatment provided the same estimated ME intake as the supplements offered to the control cows, and had the same ratio of grain:forage (78:22 DM basis).
(3) **PMR**: Cows grazed perennial ryegrass pasture twice daily at the same allowance as the control and FGM cows. They were also offered a PMR comprising milled wheat grain, crushed corn