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Assessment of dietary ratios of red clover and corn silages on milk production and milk quality in dairy cows

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ABSTRACT

Twenty-four multiparous Holstein-Friesian dairy cows were used in a replicated 3 × 3 Latin square changeover design experiment to test the effects of changing from corn (*Zea mays*) silage to red clover (*Trifolium pratense*) silage in graded proportions on feed intakes, milk production, and whole-body N and P partitioning. Three dietary treatments with ad libitum access to 1 of 3 forage mixtures plus a standard allowance of 4 kg/d dairy concentrates were offered. The 3 treatment forage mixtures were, on a dry matter (DM) basis: (1) R10: 90% corn silage and 10% red clover silage, (2) R50: 50% corn silage and 50% red clover silage, and (3) R90: 10% corn silage and 90% red clover silage. In each of 3 experimental periods, there were 21 d for adaptation to diets, and 7 d for measurements. Diet crude protein intakes increased, and starch intakes decreased, as the silage mixture changed from 90% corn to 90% red clover, although the highest forage DM intakes and milk yields were achieved on diet R50. Although milk fat yields were unaffected by diet, milk protein yields were highest with the R50 diet. Whole-body partitioning of N was measured in a subset of cows (n = 9), and both the daily amount and proportion of N consumed that was excreted in feces and urine increased as the proportion of red clover silage in the diet increased. However, the apparent efficiency of utilization of feed N for milk protein production decreased from 0.33 g/g for diet R10 to 0.25 g/g for diet R90. The urinary excretion of purine derivatives (sum of allantoin and uric acid) tended to increase, suggesting greater flow of microbial protein from the rumen, as the proportion of red clover silage in the diet increased, and urinary creatinine excretion was affected by diet. Fecal shedding of *E. coli* was not affected by dietary treatment. In conclusion, even though microbial protein flow may have been greatest from the R90 diet, optimum feed intakes and milk yields were achieved on a diet that contained a 1:1 DM mixture of corn and red clover silages.

Key words: corn silage, milk production, nitrogen balance, red clover silage

INTRODUCTION

Red clover (*Trifolium pratense*) is an important crop for producing high protein silage in North America and northern Europe. As a legume, its ability to fix atmospheric N means that no fertilizer N applications are required for its cultivation, and this makes it an important crop in organic or other low-input farming systems. Red clover is a relatively short-term crop (2–3 yr), and the accumulation of fixed N in soil following a crop of it makes it suitable as part of a soil fertility-building rotation with other crops such as corn (*Zea mays*; Stute and Posner, 1995; Huss-Danell et al., 2007). The N fixed by the legume can thus be used in the production of both energy- and protein-rich forages. The efficiency of use of N in protein-rich forages such as legume silages is often low, as a result of low concentrations of an energy source such as starch or water-soluble carbohydrates. Legume silages, such as red clover silage, are thus best fed mixed with another crop that can provide rumen-available energy to improve the capture of rumen-degradable protein. Corn silage offers this potential, with relatively high concentrations of starch being provided. Recent work investigating the use of red clover silage as the sole forage showed improvements in milk yields, compared with grass silage alone, largely through improvements in feed intake (Bertilsson and Murphy, 2003; Dewhurst et al., 2003; Al-Mabruk et al., 2004). However, Moorby et al. (2009), comparing mixtures of red clover and ryegrass silages, concluded that the optimum milk yields were achieved with a ratio of 66% red clover silage in the forage component of the diet. Similar results were found by Halmemies-Beauchet-Filleau et al. (2014), who found increased feed intakes and milk yields from feeding mixtures of grass and red clover, compared with them being fed alone, whereas Vanhatalo et al. (2009)

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found highest feed intakes by cows offered a 1:1 mixture of the 2 silages, but this did not translate to improvements in milk yields.

Most strains of *Escherichia coli* are commensal although the O157 strain is pathogenic in humans, with cattle being an important potential source of contamination of the food chain (Wells et al., 1991; Zhao et al., 1995). The cattle diet, and particularly its starch concentration, can significantly influence (reduce or increase) fecal shedding of *E. coli*, including the O157 strain (Callaway et al., 2009), whereas feeding of red clover hay has been shown to reduce the amount of *E. coli* in cattle rumen contents (Jacobson et al., 2002).

The hypothesis of this study was that mixing corn and red clover silages in varying proportions would improve the milk production from multiparous dairy cows and improve the efficiency of nitrogen utilization for milk production. It was also hypothesized that changing the ratio of red clover silage to corn silage may alter the fecal bacterial population, including *E. coli* O157 populations. The objectives of this experiment, therefore, were to investigate the effect of mixing red clover and corn silages at different ratios on feed intake, milk production, and whole-body N partitioning in dairy cows. Diet effects on gut pathogens were also investigated by studying feces.

MATERIALS AND METHODS

Cows and Management

All procedures used in this experiment were licensed and regulated by the UK Home Office under the Animals (Scientific Procedures) Act of 1986. The experiment used 24 multiparous Holstein-Friesian dairy cows, which had a mean weight of 623 (SD = 51.4) kg and 106 (SD = 16.1) DIM at the start, in a 3 × 3 Latin square design with 8 replicated squares. Cows were kept in a freestall barn at all times, apart from a subset of 9 cows (3 per treatment) that were transferred to a metabolism unit for feed digestibility and N partitioning measurements for 10 d during each period of the experiment. Each experimental period lasted 28 d, comprising an adaptation period (the first 21 d) and a measurement period (the last 7 d).

For 3 wk before the start of the experiment, all animals were fed a common covariate diet with ad libitum access (to ensure refusals of at least 0.1 of the quantity offered) to ryegrass silage and red clover (1:1 mix on a fresh matter basis) plus 4 kg/d per cow of a standard purchased dairy concentrate feed (Dairy HC 18 pellets, Welsh Feed Producers, Carmarthen, UK). Cows were assigned to 1 of the 8 replicate Latin squares of 3 animals based on milk yield data collected over the week before the start of the experiment. Animals were ranked from highest to lowest milk yields, and the top 3 yielding cows were then allocated to square 1, the next 3 yielders to square 2, and so on with the lowest 3 yielding animals allocated to square 8. Within each Latin square, animals were allocated at random to each of the 3 treatments. Cows in Latin squares 1, 4, and 7 were used for digestibility and whole-body N and P partitioning measurements.

Three dietary treatments were used in the experiment. These consisted of ad libitum access to 1 of 3 forages, comprising mixtures of corn and red clover silages, together with an allowance of 4 kg (fresh) of the same concentrate per day (offered as 2 kg at each milking, at approximately 0500 and 1500 h). The forage treatments, prepared on a DM basis, were (1) **R10**, 90% corn silage:10% red clover silage; (2) **R50**, 50%:50% corn silage:red clover silage; and (3) **R90**, 10%:90% corn silage:red clover silage. The corn silage was not fed at 100% rates to avoid known potential issues associated with high starch concentrations, low protein concentrations, short fiber lengths. Although red clover silage fed as a sole forage is unlikely to cause problems, the R90 diet mix was prepared as the logical opposite to the R10 mix. The corn silage was prepared as a large bunker from a corn crop harvested with a self-propelled forage harvester fitted with a corn cracker, and using an inoculant (Sil-All Fireguard, Alltech UK, Stamford, UK; containing *Lactobacillus plantarum*, *Enterococcus faecium*, *Lactobacillus salivarius*, and *Pediococcus pentosaceus*) at manufacturer's recommended application rates (10^6 cfu/g of fresh forage). The red clover silage was prepared as big round bales from second and third cuts of a monoculture sward of red clover (cv. Milvus), using an inoculant (Powerstart, Genus plc, Nantwich, Cheshire, UK; containing *Lactobacillus plantarum*) ensiling at the manufacturer's recommended rates (10^6 cfu/g of fresh forage); the red clover crop was not chopped before baling. During the experiment, the red clover used was a mixture of the 2 silage cuts in a ratio of 2 bales first cut to 1 bale third cut. The concentrate feed had a declared ingredient list of wheat (35% of the fresh matter), extracted rapeseed meal (17.5%), corn meal (10%), palm kernel expellers (10%), molasses (6%), field beans (5.25%), soybean meal (5%), wheatfeed (4.05%), extracted sunflower meal (3%), vegetable oil (1.6%), and a mineral and vitamin mix (2.6%).

The 3 corn and red clover mixes were prepared by thorough mixing in a Storti Labrador 120 mixer wagon fitted with a chopping auger (Ruston's Engineering Co. Ltd., Huntingdon, UK). Forage was dispensed into individual feed bins of forage intake control feeders (Insentec B.V., Marknesse, the Netherlands) to allow automatic recording of ad libitum feed intakes in the