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Utilisation of white clover pasture and maize silage by the lactating dairy cow

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ABSTRACT

White clover herbage in the vegetative stage of growth has a high nutritive value for milk production, but the high crude protein content could be better utilised if cows were given a suitable readily fermentable carbohydrate source. Six rumen fistulated Friesian cows in late lactation were housed in metabolism cages and fed either fresh white clover herbage or white clover and maize silage (50:50). The experiment was a cross over design that allowed measurement of nutrient intake, rumen function and milk production.

At similar digestible organic matter intakes (9.6 kg/d vs 9.9 kg/d), replacing 50% of the white clover dry matter with maize silage reduced crude protein intake by 30% (3 kg/d vs 2.1 kg/d), and urinary N excretion from 251 gN/d to 137 gN/d without affecting milk yield (12.6 l/d vs 12.5 l/d) or milk protein output (400g/d vs 413 g/d). Rumen pH was similar for both treatments (6.1 vs 6.0) but there was a higher utilisation of neutral detergent fibre (2.6 kg/d vs 3.4 kg/d) when the cows were fed the mixed diet. The excess intake of nitrogen when the cows were fed white clover only was calculated to be largely wasted as ammonia absorbed from the rumen and excreted as urinary urea.

Keywords: White clover, maize silage, dairy cow, digestibility, protein utilisation.

INTRODUCTION

White clover herbage has a relatively high nutritive value for milk production (Rogers *et al.*, 1982; Holmes and Wilson, 1987). In a stall feeding experiment with lactating cows offered either fresh white clover or ryegrass herbage *ad libitum*, Rogers *et al.* (1982) found that those fed white clover consumed more DM and produced more milk. Further, when all cows were offered the same but restricted amounts of herbage, the cows fed white clover produced more milk compared to cows fed ryegrass.

Nevertheless, a limiting factor to the nutritive value of white clover (like most improved herbages in the vegetative stage of growth) is the imbalance of the major feed components. White clover herbage is relatively low in available energy, particularly readily fermentable carbohydrate, and usually contains more than adequate levels of crude protein (CP) for milk production.

It has often been suggested (e.g., Corbett, 1987) that excess herbage CP could be better utilised by supplementation with a readily fermentable carbohydrate. This form of energy can be used by rumen micro-organisms to promote microbial activity (Dellow *et al.* 1988) and growth (Rooke *et al.* 1987) thereby improving the utilisation of the excess herbage CP.

In the irrigated dairying zone of northern Victoria, grain supplementation (barley, oats or wheat) to grazing cows is commonly used to boost milk production per cow and per hectare. Maize silage is another supplement option. Maize silage can contain up to 30% starch, and it also supplies additional fibre which avoids some of the problems which can occur with feeding high levels of grain. The data presented here is from one of a series of experiments at Kyabram Centre aimed at assessing the potential of white clover herbage supplemented with maize silage for milk production.

MATERIALS AND METHODS

Animals

The experiment was a simple cross-over design. Six Friesian cows (age, 3 to 7 yr; BW, 378 to 531 kg) in late lactation (31 weeks) were housed indoors in individual metabolism stalls for two, ten day periods and fed either fresh white clover (*Trifolium repens* var. Haifa), or a 50:50 (DM basis) diet of white clover herbage and maize (*Zea mays*) silage. Feed was offered at 90% of *ad libitum*, as determined during a 14 day preliminary feeding period during which the diets were given *ad libitum* to individual cows held on a rice hull feeding pad. Drinking water was freely available. The animals were fitted with faecal collection harnesses and urine separators and machine milked twice daily. Five of the animals were fitted with a removable rubber, rumen cannula.

Diets

The white clover was harvested daily from irrigated stands maintained through cutting sequences to provide herbage of consistent height (10 to 15 cm). Maize silage was produced on farm the previous autumn, from maize harvested at the hard dent stage of maturity using a precision chop harvester, and stored in a concrete bunker. During both experimental periods the cows were fed the diet from automatic belt feeders adjusted to provide feed hourly. Fresh herbage was spread evenly on the feeder belts twice daily, and for the three cows offered the mixed diet the maize silage was spread on top

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of the white clover. Anti-bloat oil (60 ml) was sprinkled on top of the white clover.

Measurements

Daily measurements were made of intake, faecal and urine output, and milk production, and samples collected. In the latter five days of each experimental period, a Cr-EDTA solution was continuously infused in to the rumen of fistulated cows. Rumen digesta samples were taken at twelve occasions over the last three days (to represent 2 hourly sampling over a 24 h period) to determine pH, ammonia and volatile fatty acid (VFA) concentration to indicate rumen function, and a fluid sample was analysed for Cr to determine rumen fluid outflow rate. At the end of the three day rumen sampling period, each of the five rumen fistulated cows was emptied of rumen contents, the contents rapidly weighed and samples obtained for other analyses and calculation of rumen pool sizes, and the digesta returned to the rumen.

Forage, rumen digesta and faecal samples were freeze dried, then ground to pass through a 1mm sieve. Residual DM was determined by drying at 100°C for 24 h and samples were ashed at 520 C for three hours to determine ash content. Feed samples were analysed for *in vitro* digestibility according to a two stage rumen fluid method (Tilley and Terry, 1963) and nitrogen determined using an automatic micro-Kjeldahl analyser (Tecator 1030 analyser). Neutral detergent fibre (NDF) was analysed by the method of Goering and Van Soest (1970). Rumen ammonia concentrations were determined with the microdiffusion method of Conway (1957) and VFA concentration was measured by gas chromatography (Ziolecki and Kwiatkowska, 1973). Rumen fluid samples were analysed for Cr concentration by atomic absorption spectrophotometry. Rumen fluid outflow was calculated from the infusion rate of Cr-EDTA divided by the concentration of Cr in the rumen fluid. Treatments were compared statistically by analysis of variance (Genstat V).

RESULTS AND DISCUSSION

The white clover herbage and the maize silage contained (g/kg DM); 36.2 and 10.7 g N, 894 and 944 g OM, 291 and 469 g NDF, respectively. White clover herbage DM content varied daily with a mean DM of 181 g/kg of wet weight (range; 120 to 264 g/kg). Maize silage DM content was more constant with a mean DM of 342 g/kg of wet weight (range; 323 to 370 g/kg).

The cows consumed similar amounts of apparently digestible OM of both the white clover and the mixed diet of white clover/maize silage diet (Table 1), even though OM intakes differed by 10% ($P<0.05$). This was due to two factors; the maize silage contained considerably less ash than the white clover (57 g/kg DM vs 106 g/kg DM, respectively), and white clover OM was more digestible than the mixture of white clover/maize silage OM (0.79 vs 0.75, $P<0.01$). Milk production was similar on both diets.

Although intake of digestible OM was similar, the composition of the two diets offered differed considerably. Intake of CP was 30% higher when the cows were fed white clover only ($P<0.001$). Maize silage is low in CP (67 g/kg DM in this experiment) and when the cows were fed the mixed diet this effectively diluted CP intake, but the reduction in CP intake did not affect milk protein output.

TABLE 1: Intake, digestion, urine output and milk production in six cows fed white clover (WC) or white clover plus maize silage (WC+MS)

Diet	WC	WC+MS	Significance
Intake (kg/d):			
Organic matter	12.0	13.2	*
Crude protein	3.0	2.1	***
Neutral detergent fibre	3.9	5.4	***
Digestion:			
Organic matter	0.791	0.746	**
Crude protein	0.792	0.711	***
Neutral detergent fibre	0.684	0.628	**
Digestible intake (kg/day):			
Organic matter	9.6	9.9	NS
Crude protein	2.4	1.5	***
Neutral detergent fibre	2.6	3.4	***
Urine:			
Volume (l/day)	29.6	16.3	***
Nitrogen (g/day)	251	137	***
Milk production:			
Volume (l/day)	12.6	12.5	NS
Nitrogen (g/day)	64	66	NS

* $P< 0.05$, ** $P<0.01$, *** $P<0.001$

At the higher level of CP for the white clover only diet, the cows apparently absorbed more CP from the gut ($P<0.001$) as there was no change in faecal excretion of N. Nor was there any increase in the amount of N secreted in milk; the extra N absorbed from the gut was excreted in the urine, mainly as urea.

A major proportion of the dietary CP of fresh herbages is not utilised directly by the ruminant; it is degraded in the rumen and excess ammonia not used for rumen microbial protein production is absorbed. From experiments with grazing cattle, Ulyatt *et al.* (1988) suggested that a net loss of nitrogen (N) from the rumen, through absorption of ammonia, occurs when fresh herbages contain more than 25.5 g N/kg organic matter (OM) (equivalent to approximately 180 g CP/kg dry matter).

In the present experiment, the white clover diet contained 40.3 gN/kg OM and the mixed diet contained 25.9 gN/kg OM. Given that the white clover fed cows consumed 12 kg of OM, and using the calculation of Ulyatt *et al.* (1988), this suggests a net absorption 122 g of ammonia-N from the rumen of the cows fed the white clover diet compared with 2 g of ammonia-N on the mixed diet. In the present experiment the cows fed the white clover diet excreted an additional 114g of N in urine, so that most of the extra ammonia absorbed from the rumen was excreted as urea by this route.

Rumen function was not impaired by inclusion of 50% of the diet as maize silage (Table 2). When the cows were fed the mixed diet rumen ammonia concentrations were lower, (199 vs 143gN/l) but did not fall below minimum levels usually considered to be necessary for efficient microbial growth (Satter and Slyter, 1974).

In both groups rumen pH was similar and the small differences in VFA concentrations between treatments were not significant. The rumen pool size of non-ammonia-N was

TABLE 2: Rumen function in five cows fed white clover (WC) or white clover plus maize silage (WC+MS)

Diet	WC	WC+MS	Significance $p < 0.05$
pH	6.08	6.01	NS
Rumen fluid outflow (l/h)	10.3	10.4	NS
Rumen pool sizes			
Fluid (l)	69.4	62.2	NS
Dry matter (kg)	8.2	9.1	NS
Organic matter (kg)	7.2	8.2	NS
Non-ammonia-nitrogen (kg)	3.4	2.3	*
Neutral detergent fibre (kg)	4.1	5.9	*
Ammonia-nitrogen (g)	13.8	8.9	*
Volatile fatty acids (mols)	8.6	7.3	NS

lower and pool size of NDF was higher when the cows were fed the mixed diet, but there was no change in flow of fluid from the rumen. The amounts of NDF digested was greater in cows given the mixed diet than clover alone.

CONCLUSIONS

White clover herbage can be substituted with maize silage to a significant proportion of the total diet without impairing milk production in cows in late lactation. In this experiment the maize silage effectively improved the utilisation of the herbage protein.

The level of maize silage fed in this experiment did not impair rumen function. When the cows were fed a 50:50 mixture of white clover/maize silage the amounts of ammonia and CP in rumen digesta were considerably reduced, reflecting the decrease in CP intake, but there was no change in milk production nor in milk protein output.

However, the level of substitution will depend on the CP content of the herbage on offer, and on the total CP intake in order to maintain milk production.

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