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Balancing pasture and maize silage diets for dairy cows using urea, soybean meal or fishmeal

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ABSTRACT

Four treatment groups of 10 Holstein-Friesian cows were established at the DRC No. 2 dairy in the spring, summer and autumn of 1996/97 to test the efficacy of providing urea, soybean meal or fishmeal supplement to overcome the protein deficiency that occurs when cows are supplemented with large amounts of maize silage. Pasture allowance was manipulated to achieve an average pasture dry matter (DM) intake of 6.6kg/cow/day for each group. Treatment groups were supplemented with 75 MJ ME/cow/day as either 7.0kg DM of maize silage, 7.0kg DM of maize silage plus 90g of urea, 5.2kg DM of maize silage plus 1.4kg DM of soybean meal, or 5.8kg DM of maize silage plus 1.0kg DM of fish meal. The addition of urea as a source of non-protein nitrogen had no effect on milk, milkfat or milk protein production. Soybean meal increased milk protein production by 0.06kg/cow/day in both summer and autumn ($P<0.01$). Fishmeal increased milkfat production by 0.07 ($P<0.01$) and 0.08kg/cow/day ($P<0.05$) in summer and autumn and increased milk protein by 0.06 ($P<0.01$), 0.10 ($P<0.01$) and 0.08kg/cow/day ($P<0.001$) in spring, summer and autumn, respectively.

Keywords: dairy production; maize silage; urea; soybean meal; fishmeal.

INTRODUCTION

It is usually assumed that energy intake limits milk production from cows grazing high quality pastures. Also at some stages of the NZ milk production season, cows are constrained by the availability of feed (Bryant, 1990). To remove this constraint maize silage is being increasingly used as a cheap source of additional feed. However maize silage has a crude protein (CP) content of only 6-8%. High producing dairy cows require a CP content of 14-18% in the total diet (Holmes & Wilson, 1987). At high feeding levels of maize silage, or when the CP content of the pasture is low, milk production responses to maize silage may be limited through a gross protein deficiency or through a specific amino acid deficiency. Therefore adding a protein supplement should increase milk production.

It is widely recognised that when pasture fed cows are offered high rates of maize silage protein intake is likely to limit milk production (Hutton & Douglas, 1975). Urea is often advocated as a cheap N supplement. However the National Research Council (NRC) protein requirement estimations suggest that pasture alone has insufficient undegradable protein (UDP) for high levels of milk production. This estimated deficiency is increased in a diet consisting of pasture and maize silage. It is likely that both total protein intake and the rate the protein is degraded in the rumen effects the efficacy of protein supplements offered with maize silage.

Penno *et al.,* (1995) reported that feeding cows fishmeal at the rate of 150g or 300g UDP/cow/day for 8 weeks in mid Spring had no effect on milk yield or milksolids production. Rusdi and Van Houtert (1997) suggested that neither metabolisable protein (MP) supply nor methionine/lysine supply were limiting milk production in dairy cows grazing ryegrass-based pastures during early or late lactation. However the response to protein supplements of cows fed fermented forages which are low in CP are likely to be considerably different than that for cows grazing pasture alone. Based on this hypothesis, these experiments were designed to determine the ability of urea, soybean meal (SBM) or fishmeal (FM) to correct a protein deficiency created by supplementing grazing dairy cows with large amounts of maize silage.

MATERIALS AND METHODS

Four treatment groups of 10 high genetic merit Holstein-Friesian cows were established in the spring (17 September 1996), summer (17 January 1997) and autumn (28 March 1997) at the DRC No. 2 dairy. Cows were grazed together for 2 weeks prior to the trial and their milk production and liveweight in the second week used for covariate analysis. In the pre-trial period the cows were offered 5kg DM/cow/day as maize silage. Each experimental period was conducted for 4 weeks. At the start of each period the treatment groups were balanced on age, liveweight, calving date and previous milk, milkfat and protein production.

At the start of spring, summer and autumn trial periods, mean cow liveweight was 400, 433 and 453kg and body condition score was 4.3, 4.3 and 4.2 respectively.

During each experimental period the pasture allowance was manipulated to attempt a pasture dry matter intake (DMI) of 7.0kg/cow. In addition to pasture, up to 7.0kg DM/cow/day of maize silage was offered. The treatment groups were offered either no protein supplement (Control), urea as a non-protein nitrogen, SBM as a rumen degradable source of protein, or FM as an undegradable protein source (Table 1). To ensure that minerals were not deficient in the diet, the pasture and maize silage were analysed for each trial period and mineral supplements included according to NRC (1989). The pasture and maize silage was analysed by Near Infrared Reflectance spectrometry (NIR) for chemical composition. In the spring, maize diets included 120g/cow/day of dicalcium phosphate, 30g of lime flour, 40g of salt and 20g of magnesium oxide and in the summer and autumn the dicalcium phosphate was reduced to 100g. The total supplement offered to each group was kept isocaloretic by adjusting the amount of maize silage to account for the metabolisable energy (ME) provided by the protein supplements.

TABLE 1: Drymatter intake (DMI) of pasture, maize silage and protein supplements.

	Control	Urea	Soybean meal	Fishmeal
Pasture intake (kg DMI/cow/day)	6.6	6.6	6.5	6.5
Maize silage (kg DMI/cow/day)	7.0	7.0	5.2	5.8
Protein supplement (g/cow/day)	0	90	1400	1000
Crude protein in supplement (g/cow/day)	0	259	700	700
RDP in supplement (g/cow/day)	0	259	455	280
UDP in supplement (g/cow/day)	0	0	245	420

Treatment groups grazed the same paddock separated by electric fences. The maize silage and the respective protein treatment was offered to the groups in a trough that the cows had access to while grazing. The dry additives were mixed with the silage and the urea was diluted in water and sprinkled onto the top of the silage prior to feeding.

The cows were weighed and body condition scored as described by Macdonald & Macmillan (1993) after the morning milking on two successive days at the start and end of each trial period. Milk yield was measured on two consecutive milkings each week and a sub-sample analysed for milkfat, protein and lactose content by Milkoscan. Pasture intake was estimated from 3 occasions each week by DM disappearance based on visual assessment of pre- and post grazing herbage mass (Stockdale, 1984). Composite pasture and treatment supplementary feed samples for each week were analysed by NIR to indicate the CP, acid detergent fibre (ADF), neutral detergent fibre (NDF) and metabolisable energy (ME) levels.

The cows were randomised to the treatments and balanced for cow age, days in milk, liveweight, body condition score, milkfat and milk protein production during the uniformity period. Treatment effects on the liveweight, body condition score and productions were assessed by analysis of covariance using productions from the week before the trial as the covariate.

RESULTS

The mean pasture DMI measured for the respective treatments is shown in Table 2. Within season the pasture DMI of the treatment groups was similar, with the pasture DMI in the summer appearing to be marginally higher than in the spring and autumn.

TABLE 2: Mean pasture drymatter intake (DMI) (kg DM/cow/day).

	Control	Urea	Soybean meal	Fishmeal
Spring	6.9	7.1	7.1	6.9
Summer	6.2	6.5	6.3	6.2
Autumn	6.7	6.3	6.2	6.5

Table 3 shows the chemical composition of the pasture and supplement offered during each experimental period. The diet of the control herd contained an average 14.5%, 11.3% and 12.6% crude protein in spring, summer and autumn, respectively. This is below the recommended protein levels (16-18% for cows producing >18*l*, and 14-16% for 9-17*l* of milk) required by lactating dairy cows. Urea increased the CP above the control by 2% and SB and FM increased it bu 5%, across all periods. The control herd consumed 160, 146 and 156 MJME/cow/day in the spring, summer and autumn, respectively. The *invitro* DM digestibility of the pasture on offer to the cows was 79.5, 75.0, and 77.1% for the spring, summer and autumn, respectively. Although there were small differences in the ME concentration of the total diet (Table 3) these were accounted for with differences in DMI, resulting in similar ME intake between treatment groups.

TABLE 3: Crude protein, acid detergent fibre (ADF), neutral detergent fibre (NDF) and metabolisable energy (ME) content of the pasture and maize silage offered during each experimental period.

		Crude Protein g/100g DM	ADF g/100g DM	NDF g/100g DM	ME MJ/kg DM
Pasture					
	Spring	22.8	20	38	12.6
	Summer	16.9	25	47	11.8
	Autumn	19.5	23	42	12.2
Maize silage					
	Spring	6.8	27	50	10.5
	Summer	6.7	27	45	10.4
	Autumn	6.7	26	42	10.6
Total diet					
Spring	Control	14.5	18.2	43.4	11.4
	Urea	16.3	18.3	43.3	11.4
	Soybean meal	19.2	18.4	42.3	11.9
	Fish meal	19.2	18.4	42.7	11.3
Total diet					
Summer	Control	11.3	25.6	45.4	10.9
	Urea	13.3	25.6	45.5	10.9
	Soybean meal	16.1	25.4	45.5	11.4
	Fishmeal	16.2	25.5	45.5	10.8
Total diet					
Autumn	Control	12.6	24.1	41.1	11.2
	Urea	14.4	24.1	41.4	11.2
	Soybean meal	17.4	23.9	41.3	11.7
	Fishmeal	17.5	24.0	41.4	11.1

The addition of urea as a source of non-protein nitrogen had no effect on milk, milkfat or milk protein production (Table 4). The inclusion of SBM increased milk protein production by 0.06kg/cow/day in both summer and autumn (P<0.01). Inclusion of FM increased milkfat production by 0.07 (P<0.01) and 0.08kg/cow/day (P<0.05) in summer and autumn and milk protein by 0.06 (P<0.01), 0.10 (P<0.01) and 0.08kg/cow/day (P<0.001) in spring, summer and autumn, respectively.

The use of FM gave a milk yield response in all three periods, whereas a milk yield response to SBM was only obtained in autumn. The milkfat content of milk was reduced when urea and FM were included during summer, and increased when urea was fed in autumn. Milk protein content of milk was increased in spring and summer when SBM was included and was lowered in summer when urea was fed.

Supplementing with SBM increased liveweight gain during summer (P<0.01) and FM increased liveweight gain during summer (P<0.05) and autumn (P<0.01) (Table 4).

DISCUSSION

Hutton and Douglas (1975) concluded that the milk production of grazing dairy cows would be limited by protein deficiencies once maize silage comprised more than 33% of the total diet. Adding urea to maize silage is often advocated as a cost effective method of increasing the crude protein intake of dairy supplemented with maize silage (Phillips 1988). However, during these experiments supplementing cows with urea had no effect on milksolids yield. Experiments where the use of urea has improved milksolids yield have generally been conducted where the urea and maize silage is offered as part of a total mixed ration (Sauer *et al.*, 1979). Experiments where urea has been offered only twice daily have resulted in no increase in milk yield (Erfle *et al.*, 1978). A possible reason for the lack of response may be the large fluctuations in rumen ammonia levels that have been associated with infrequent feeding of urea (Coppock *et al.*, 1976).

In contrast to the urea treatment, FM and SBM increased both production and liveweight gain in summer and autumn. Moran and Stockdale (1992) also demonstrated the importance of adding a true protein supplement when maize silage is offered at a high proportion of the diet by supplementing with cotton seed. During summer and autumn the SBM and FM treatments resulted in similar milksolids yield. The simultaneous increase in milksolids production and liveweight gain suggests that the SBM and FM treatments increased the digestibility of the total diet. The lack of response from the urea may suggest the rate of digestion of the protein supplement should be similar to that of the maize silage to provide synchrony between the availability of ammonia and microbial activity.

These experiments have shown that when feeding maize silage as a large proportion of the diet (~50%), rectifying protein deficiencies can improve milk production performance. The form of this nitrogen is important. Nitrogen from protein is more valuable than non-protein N sources (urea), this is probably due to the microbial requirements for NH_3 being better supplied by slowly degradable protein supplements rather than at a faster rate by non-protein N. In all three experimental periods fishmeal was significantly better than urea for the production of milk protein and milkfat, whereas soybean meal was only

TABLE 4: Mean milk yield and composition measured during the experimental period and liveweight and body condition score at the end of each period.

Period		Control	Urea	Soybean meal	Fishmeal	SED
Spring	Milk (kg/cow/day)	17.9	16.9	17.5	19.1*	0.5
	Milkfat %	4.51	4.50	4.67	4.32	0.13
	Protein %	3.18	3.26	3.34**	3.29	0.05
	Milkfat (kg/cow/day)	0.80	0.76	0.81	0.83	0.03
	Protein (kg /cow/day)	0.57	0.55	0.58	0.63**	0.02
	Liveweight (kg)	398	396	403	394	5
	Body condition score	4.23	4.22	4.31	4.26	0.11
Summer	Milk (kg/cow/day)	10.5	11.0	11.7	13.1*	0.8
	Milkfat %	5.46	5.17*	5.27	4.81***	0.12
	Protein %	3.67	3.52*	3.81*	3.59	0.07
	Milkfat (kg/cow/day)	0.56	0.57	0.61	0.63**	0.03
	Protein (kg /cow/day)	0.38	0.39	0.44*	0.48**	0.03
	Liveweight (kg)	439	438	453**	451*	6
	Body condition score	4.16	4.33	4.38*	4.32	0.09
Autumn	Milk (kg/cow/day)	9.0	8.9	10.5**	11.1***	0.8
	Milkfat %	5.45	5.95*	5.33	5.27	0.19
	Protein %	3.78	3.88	3.85	3.86	0.07
	Milkfat (kg/cow/day)	0.50	0.52	0.56	0.58*	0.03
	Protein (kg /cow/day)	0.34	0.34	0.40**	0.42***	0.02
	Liveweight (kg)	461	461	464	471*	5
	Body condition score	4.10	4.13	4.18	4.16	0.12

significantly different *(P<0.05) **(P<0.01) ***(P<0.001).

significantly better than urea for milk protein production in the autumn.

CONCLUSION

If maize silage is to comprise ~50% of the diet of grazing dairy cows a true protein supplement will be required for optimum digestion and milksolids production. Adding urea to increase the crude protein content of maize silage will not improve dairy cow performance when the is silage offered as a supplement to pasture.

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