

AMOUNT AND SOURCE OF PROTEIN IN CONCENTRATES FED TO HIGH PRODUCING DAIRY COWS IN A SUB-TROPICAL FEEDING SYSTEM

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SUMMARY

Milk production and composition were measured in 36 autumn calving Holstein-Friesian cows fed supplements of rolled barley grain (12.8% CP) or iso-nitrogenous barley grain/protein meal mixtures (16.4% CP) containing meat and bone meal, cottonseed meal or formaldehyde treated sunflower meal (Norpro[®]) with irrigated temperate pastures plus maize silage and tropical grass. Concentrates were fed twice daily at 8 kg/cow.day for 16 weeks in early lactation. Effective rumen degradability (ERD) of the protein of each feed component was 64%, 39%, 53% and 35% respectively for barley grain, meat and bone meal, cottonseed meal and formaldehyde treated sunflower meal. Addition of protein meal to the supplement increased milk yields from 24 to 27 litres/cow.day ($P < 0.01$) and increased yields of butterfat, milk protein and lactose ($P < 0.05$) but had no significant effect on milk composition or liveweight gain. There were no significant differences in yield or composition of milk by cows fed the different protein meals. In this study, dietary protein intake rather than protein degradability was more limiting for cows fed high levels of supplements with temperate pastures and maize silage.

Keywords: milk, supplementation, protein, degradability, temperate pasture, maize silage

INTRODUCTION

In northern Australia, dairy farmers supply a whole milk market requiring a consistent level of production throughout the year. Seasonal variability in the sub-tropics prevents farmers from using a single forage source year round and pasture systems based on tropical species in summer/autumn and irrigated temperate species in winter/spring have been developed (Moss and Lowe 1993). Between 1 and 3 tonnes of concentrate per cow is now fed each lactation in Queensland herds to increase milk production and improve pasture utilisation. In earlier studies of sub-tropical milk production systems, a concentrate protein content $\geq 16\%$ was necessary to maintain a dietary protein content above 16% for lactating cows when energy content of the diet was increased with cereal grain and/or maize silage (Moss *et al.* 1992, 1994). Protein supplements which are resistant to rumen degradation may further increase milk yields (Stobbs *et al.* 1977; Kung and Huber 1983; Hamilton *et al.* 1992). In this study a similar feed system was used and milk yield and composition were measured in cows fed 8 kg/day (fresh weight) of rolled barley grain or 1 of 3 different iso-nitrogenous barley grain/protein meal mixtures that varied in rumen degradability. Supplements were similar in energy and fed with a forage diet based on irrigated temperate pastures, tropical grass and maize silage.

MATERIALS AND METHODS

The experiment was conducted between April and September 1994 at Mutdapilly Research Station south-west of Brisbane (latitude 27° 46'S; longitude 152° 40'E; altitude 40 m) in a sub-coastal, sub-tropical environment. The region experiences warm to hot summers and cool winters with mean maximum/minimum temperatures ranging from 31°C/21°C in January to 20°C/5°C in July, with numerous frosts between June and September. Rainfall is of predominantly summer incidence averaging 800 mm per annum. Pastures were established on heavy black (Ug 5.16) and grey (Ug 5.24) alluvial clay soils. Raingrown perennial Rhodes grass pastures (*Chloris gayana* cv. Pioneer (70%) and cv. Callide (30%)) provided feed in summer-autumn and a separate area of irrigated temperate pasture was used in winter-spring. These latter pastures were a mixture of white clover, (*Trifolium repens* cv. Haifa), shaftal clover (*Trifolium resupinatum*), lucerne (*Medicago sativa* cv. Sequel) and annual ryegrass (*Lolium multiflorum* cv. Concord). Tropical grass pastures were fertilised with 250 kg super-phosphate, 125 kg muriate of potash and 650 kg urea/ha in the preceding summer, while the temperate pastures received 200 kg/ha of a mixed fertiliser (CK88 - 14.8% N, 4.3% P, 11.3% K, 13.4% S) in April and were top dressed with urea at 125 kg/ha after the third grazing. Tropical grass pastures were stocked at 2.5 cows/ha. Temperate pastures were stocked at 4.5 cow/ha and grazed once daily between morning and afternoon milkings from May to July and at night from August to September. Maize silage was fed with tropical grass for 1 period per day throughout lactation. From May to July maize

silage was fed to appetite and from August restricted to 5 kg DM/cow.day. Sodium bicarbonate (250 g/cow.day) and salt (50 g/cow.day) were supplied in the maize silage. Cows were offered pastures and silage as a single group.

Twenty-four Holstein-Friesian cows and 12 heifers calving in autumn 1994 (April-May) were stratified on age, production and calving date and randomly allocated to 4 supplementation treatments using rolled barley grain (B) alone or mixed with meat and bone meal (MM) (10B/1MM); cotton seed meal (CSM) (8B/1CSM) or formaldehyde treated sunflower meal (Norpro®) (tSFM) (5.5B/1tSFM). A commercial mineral supplement (Dairy Pak®) was included in the concentrates at 100 g/cow.day. Supplement level was increased to 8 kg/cow.day using a standard ration (barley grain plus a small amount of meat meal) for the first 2 weeks of lactation. Cows were then individually fed their respective concentrate at 8 kg fresh weight/day for 16 weeks in 2 equal feeds after milking at 0700 hours and 1600 hours each day. Dry matter content of each meal ingredient was 90%, and supplements provided 13.1, 12.7, 13.0, and 12.7 MJ ME/kg DM respectively. Refusals were negligible for all treatments. Milk yields were recorded at 2 consecutive milkings each week and a composite sample analysed for butterfat, protein and lactose (Foss Electric Milkoscan 605). Animals were weighed fortnightly after morning milking. Yield and composition of pasture on offer were determined by manually cutting and sorting for each pasture before grazing. Pasture samples for each grazing rotation were bulked for chemical analysis. Temperate pastures were strip grazed to offer a minimum of 15 kg green DM/cow.day (including tropical grass leaf before frost). Grain and protein meals were sampled twice during the experiment and analysed for nitrogen and metabolisable energy (ME) content.

Rumen liquor samples were obtained by stomach tube from all cows after morning milking (0700 hours - before a.m. supplementation, after silage) and before afternoon milking (1430 hours) once in July and analysed for ammonia. Dry matter (DM) and protein (CP) degradabilities for barley grain and the 3 protein meals were determined using the artificial fibre bag technique and calculated from an equation of the type $D = a + b(1 - e^{-ct})$ (Orskov and McDonald 1979) using a non linear regression programme (LMM) (Table 1). Rolled barley was further milled to pass through a 2 mm laboratory screen while protein meals were examined as supplied. Bags were replicated using 3 4-year old Holstein -Friesian steers fed a mix of clover/rye and lucerne hays *ad libitum* and removed after 0, 3, 6, 9, 12, 18, 24, 36 or 48 hours. Effective rumen degradability (ERD) was calculated from the equation $ERD = a + (b * c)/(c + r)$ assuming an outflow rate of 0.08 (AFRC 1993) (Table 1). Milk production data was analysed by analysis of variance.

RESULTS

Rhodes grass pasture (12.5% CP, 7.3 MJ ME/kg DM in green leaf) was the major forage source for dry and freshly calving cows in April-May but was frosted from mid June. From mid May irrigated temperate pastures (26% CP, 10.6 MJ ME/kg DM) provided the major forage component. Voluntary intake of maize silage (7.1% CP, 9.4 MJ ME/kg DM) increased to 8 kg DM/cow.day in early lactation when temperate pasture was limited but, with increasing growth of these pastures, silage was restricted to 5 kg DM/cow.day from August. Concentrate intakes were similar for all treatments. Barley grain was most rapidly degraded in nylon bags (Table 1) with 70% of the DM and 62% of the protein of rolled grain and 82% (DM) and 82% (CP) respectively for 2 mm milled grain digested in 12.5 hours. Of the protein meals, cottonseed meal protein was the most rumen degradable (62%) and formaldehyde treated sunflower meal (Norpro®) the least (41%). Meat and bone meal was intermediate (47%). Increasing the protein content of concentrate from 12.8% to 16.4% increased milk yield from 24 to 27 L/cow.day for the first 18 weeks of lactation ($P < 0.01$), with no significant effect of protein type (Table 2). Yields of butterfat, milk protein and lactose were higher for protein-supplemented than for grain-fed cows ($P < 0.05$) but milk composition was not influenced by level or type of protein in the concentrate. Cows in all treatments gained weight during the experimental period (Table 2).

Table 1. Composition (DM) and degradability coefficients of the concentrate components

Treatment	ME(MJ/kg)	CP(%)	Dry matter				Protein			
			a ^A	b ^A	c ^A	ERD	a ^A	b ^A	c ^A	ERD
B (rolled)	13.1	12.8	-1.0	90.6	0.12	53.9	-3.8	99.5	0.08	54.9
MM	8.7	55	13.4	33.2	0.77	29.7	9.8	54.1	0.09	38.7
CSM	12.2	44	21.2	59.1	0.56	45.5	15.7	78.9	0.07	52.6
tSFM	10.4	36	12.27	57.9	0.56	36.0	-0.18	100	0.04	34.9

^A Regression coefficients calculated from the equation $D = a + b(1 - e^{-ct})$ (Orskov and McDonald 1979)

Table 2. Milk yield, composition and liveweight gain by cows supplemented with barley grain or grain/protein meal mixtures

Attribute ^a	B	B + MM	B + CSM	B + tSFM	LSD 5%
Milk yield (L/day)	24.0 ^a	26.9 ^b	26.8 ^b	27.1 ^b	2.72
Butterfat (%)	3.73	3.73	4.01	3.85	0.35
Protein (%)	3.31	3.13	3.23	3.24	0.21
Lactose (%)	4.99	4.89	4.94	4.94	0.18
Butterfat yield (kg)	110 ^a	127 ^b	135 ^b	132 ^b	16.7
Protein yield (kg)	98 ^a	106 ^{ab}	108 ^{ab}	111 ^b	12.5
Lactose yield (kg)	147 ^a	166 ^b	166 ^b	170 ^b	17.9
Liveweight gain (kg)	27	24	20	30	

^aMeans with different superscripts within rows are significantly different ($P < 0.05$).

DISCUSSION

A high production feeding system was established using a combination of irrigated temperate pasture, maize silage and tropical pasture. Increasing the protein level in iso-energetic concentrates to 16.4% increased milk yields by 3 litres/cow.day in early lactation - a 12.5% response to added protein. This is greater than the 9 - 9.5% obtained in previous whole lactation studies (Davison *et al.* 1990; Moss *et al.* 1992; 1994), but protein requirements are greater in early lactation (Davison *et al.* 1990). By reverse use of feeding standards (ARC 1980), it was calculated that grain-fed cows consumed about 188 MJ ME/day. Cows fed additional protein apparently increased their intake by 16 MJ ME/day (ARC 1980). It is not possible however to attribute this increase to temperate pasture, maize silage or both as animals grazed as a single herd and individual or treatment group intakes were not measured.

In a preceding study Moss *et al.* (1994) showed that productivity of cows fed cereal (barley and/or sorghum) grains with a similar combination of temperate pasture and maize silage could be increased by increasing the protein content of concentrates above 16%. In that study it was suggested that the major response may have been due to a direct effect of additional dietary protein on rumen microbial growth. It has been suggested that high producing cows in early lactation may benefit from protein supplements of lower rumen degradability and the response might be greater if dietary protein is limiting (Orskov *et al.* 1977). In our study, rumen ammonia levels measured after maize silage was fed indicate that dietary protein supply at this time was inadequate for all treatments (Satter and Slyter 1974), with rumen ammonia concentrations of 3.0 mM/L for grain fed and 3.5 mM/L for protein supplemented cows. After grazing of temperate pastures these levels were increased to 12.2 and 13.6 mM/L respectively. The low rumen ammonia concentrations recorded after the feeding of maize silage indicated that protein supplementation in concentrates was not able to meet microbial nitrogen requirements at all times through the day and this was associated with wide variations in the protein levels of the forage components of the cow's diet.

Despite substantial differences in degradability of the 3 protein meals used in this study, there were no significant production responses to protein source, suggesting that protein availability at the small intestine was similar for cows in these treatments. Valentine and Bartsch (1995) also found no difference in milk yields of high producing cows offered supplements with cottonseed meal or meat meal in early lactation. While milk production responses to less degradable, biologically high grade protein meals have been achieved, eg formaldehyde treated casein (Stobbs *et al.* 1977), fish meal (McLachlan *et al.* 1991) and blood meal (Valentine and Bartsch 1995), these products are often not readily available to dairy farmers and/or are considerably more expensive. In this study with cows in early lactation fed high levels of dietary energy and protein and offered concentrates of similar energy content, dietary protein content rather than protein degradability was more limiting for milk production. Practical considerations for ration formulation may be largely determined in respect of protein level necessary to balance the ration and the relative cost and availability of ration ingredients. Differences in protein degradability would appear to be of only minor relevance for high yielding cows in a pasture-based production system.

ACKNOWLEDGEMENTS

We thank the Norco Dairy Co-operative, Lismore for provision of formaldehyde treated sunflower meal (Norpro[®]) used in this project and the staff at Mutdapilly Research Station for milking and feeding

management of the animals and assistance with experimental procedures. Messrs B. Burr-en and P. Van Melzin, Animal Research Institute, Yeerongpilly, carried out the chemical analyses.

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