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Effects of pasture intake and grain supplementation on milk nitrogen fractions

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ABSTRACT

Effects of underfeeding and supplementation on detailed milk components for 18 identical twin sets calving in July/August were assessed. Three treatments; 65% *ad libitum* pasture (R), 65% *ad libitum* pasture + 5.0 kg of cereal grain (S) and *ad libitum* pasture (F) were imposed in early (E), mid (M) and late (L) lactation.

Milk was analysed for contents of fat, lactose and 12 nitrogen components. Treatment effects were generally greatest in E and M and often absent in L. Differences between F and R were significant by at least P>0.05, for 10, 7 and 2 of the 12 nitrogen components for E, M, L. Comparable differences for F-S were for E 6, M 5 and L 1.

Changes were small in absolute terms and the extreme differences in type and level of feed suggest there is limited opportunity to manipulate nitrogen components in milk by feeding practices used in NZ.

Keywords: bovine; level and type of diet; milk nitrogen components.

INTRODUCTION

A current strategy of the New Zealand dairy industry is to diversify away from bulk commodities to value added consumer products and industrial ingredients. This requires improved understanding of the nature and causes of the variation in characteristics of the milk leaving the farm gate. Changes in milk composition also make it difficult for the processing sector to maintain product consistency (Hill *et al.,* 1965).

The variation is large in seasonal milk production systems both between farms and seasons. Many experiments have assessed the effect of level and type of feeding on milk composition (Bryant, 1979; Sutton and Morant, 1989, and Kolver and Bryant, 1993). The reviews of Sutton and Morant (1989), and Kolver and Bryant (1993) concluded that large increases in the protein content of milk can not be obtained by nutritive and management means. Like most previous reviewers, they considered only fat and protein content of milk.

The aim of the work reported here was to assess the effect that severe pasture restriction, and the type of feed, have on a wide range of milk properties. Only the major protein components are reported in this paper. The treatments were imposed during early, mid and late lactation since the processing and marketing sectors of the industry see differing opportunities to improve processing efficiency and product value as lactation advances.

MATERIALS AND METHODS

Animals and treatments

Eighteen sets of mixed age identical Friesian twins calving in July-August were allocated to 3 feeding regimes, to form 3 groups, balanced in order of calving date, milk yield (total solids, fat and protein) liveweight, milk protein phenotype and age. The feeding regimes were imposed during each of 3 experimental periods of 21 days in early (September, E), mid (December, M) and late (March, L) lactation. These stages of lactation represent a mean of 50, 140 and 230 days in milk. The same animals were used in each of the three periods throughout the season. Somatic cell counts averaged 33,000, 92,000 and 34,000 cells/ml for E, M and L lactation respectively.

Treatments were 65%[2] *ad libitum* pasture (R), 65% *ad libitum* pasture supplemented with 5.0 kg/cow/day of a cereal concentrate (S) and *ad libitum* pasture (F).

Treatments within each stage of lactation were assessed using an incomplete block design and a crossover design was used across the season to assess whether the changes in milk due to treatment were consistent for each stage of lactation.

Cow management

The cows were fully fed and grazed as one herd for a minimum of 4 weeks before the 21 day treatment periods. Following this uniformity period, experimental groups were grazed separately and offered a fresh area of pasture each morning. The pasture allowance in early lactation for F was 45 kg DM/cow/day and for R and S, 22 kg DM/cow/day. In early lactation insufficient pasture resulted in all groups being offered maize silage at 10% of total daily intake. In mid and late lactation pasture allowances in kg DM/cow/day were 48.5 (F) and 22.5 (R & S) and 65.3 (F) and 24.4 (R &S) respectively.

CIDR's were used during early lactation to ensure that cows did not exhibit oestrus during milk sample collection.

Sampling and Measurements during the experimental periods

Milk

The volume of milk was determined daily throughout each treatment period and its content of fat, protein and

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[2] Based on the average rate of DM disappearance of pasture

lactose, was determined for each cow, weekly. Aliquot milk samples were collected over six consecutive milkings during the final week of each treatment period and bulked to produce one sample/cow/period for detailed milk analyses.

Diet and Intake

The herbage mass of pasture before and after grazing was estimated by visual assessment, on three occasions during each week of the treatment periods. The rate of DM disappearance (kg DM/cow/day) was calculated from the difference in herbage mass before and after grazing. Representative samples of the feeds were collected during the last week of each treatment period.

Analysis

Milk

Milk yield was recorded and milk samples were analysed contents of milkfat, lactose with a Milkoscan 133B (Foss Electric, Denmark)), somatic cells (Fossamatic), crude protein (CP) (total nitrogen *6.38), non-casein nitrogen (NCN), non-protein nitrogen (NPN) by the modified International Dairy Federation (IDF) procedure, urea and bovine serum albumin and total immunoglobulin by radial diffusion. True protein (TP) was calculated as (total nitrogen-NPN)*6.38, casein as (total nitrogen-NCN)*6.38 and whey as (NCN-NPN)*6.38.

Feeds

Samples were analysed for dry matter, in vitro digestibility, neutral detergent fibre and acid detergent fibre, and crude protein (total nitrogen*6.25).

Statistical Analysis

The milk composition components were analysed using Residual Maximum Likelihood analysis (REML) to give means and standard errors of the difference between means (SED). The analysis allowed for the incomplete block design, the use of identical twins, and the crossover design across seasons.

RESULTS

Feed composition is in Table 1. The maize silage used to supplement all treatment groups in early lactation was dry matter 25.1%, crude protein 12.8%, ammoniaN:total N ratio 6.1, and digestibility 72.7%). Rate of DM disappearance of pasture for the R, S and F treatments averaged 11, 11 and 17 kg/DM/cow/day respectively.

Level of feed, type of feed and stage of lactation resulted in changes in the composition of milk (Table 2). For many components an interaction occurred between feeding regime and stage of lactation with treatment effects occurring in E and M but not L lactation.

Treatment R resulted in 23% less milksolids than F and 17% less than S. Differences in fat content were generally not significant whereas protein content for R was significantly less than F and S, in E and M but not L. Significant differences in lactose content occurred but these were small and inconsistent.

TABLE 1: Contents (g/100g DM) of dry matter (DM), crude protein (CP), in vitro organic matter digestibility (IVOMD), neutral detergent fibre (NDF) and acid detergent fibre (ADF) in pasture at early (E), mid (M) and late (L) lactation and of the cereal supplement.

	E	M	L	Cereal
DM	17.2	19.9	20.5	87.4
CP	27.7	22.8	26.4	14.1
IVOMD	83.2	79.3	75.0	81.3
NDF	45.1	47.4	49.3	34.5
ADF	14.9	22.7	22.9	13.9

TABLE 2: Composition of milk components (g/kg) in for the three treatment experimental treatments *ad libitum* pasture (F), 65% *ad libitum* pasture (R) and 65% *ad libitum* pasture plus cereal supplement (S) for the different stages of lactation (early, E; mid, M and late, L).

	Early Lactation			Mid Lactation			Late Lactation				
Milk Component	R	S	F	R	S	F	R	S	F	SED*	S Interaction
Milksolids (g/cow/day)	1382	1565	1845	1143	1408	1508	932	1158	1164	54	**
Fat	42.1	40.7	44.4	47.2	45.0	47.1	51.1	48.9	49.6	1.22	NS
Lactose	48.9	48.1	49.3	48.8	48.7	49.2	48.6	48.9	49.5	0.37	NS
Crude Protein	32.6	34.1	35.2	33.9	35.6	36.6	36.7	36.3	36.9	0.53	**
True Protein	30.1	31.7	32.5	32.0	33.8	34.2	34.5	34.1	34.7	0.55	**
Casein	25.3	26.4	27.0	26.4	27.6	28.2	28.7	28.2	28.9	0.47	*
Whey	4.81	5.36	5.51	5.66	6.22	5.97	5.79	5.86	5.84	0.185	NS
Non-Casein N	1.14	1.22	1.29	1.22	1.30	1.34	1.31	1.32	1.30	0.029	**
Non-Protein N	0.38	0.38	0.42	0.33	0.32	0.41	0.40	0.40	0.38	0.010	**
Urea N	0.22	0.20	0.26	0.15	0.14	0.22	0.23	0.22	0.21	0.007	**
BSA5	0.14	0.15	0.17	0.26	0.21	0.24	0.29	0.21	0.24	0.011	**
Total IgG6	0.40	0.47	0.47	0.53	0.52	0.53	0.70	0.60	0.62	0.045	*
True Protein/Crude Protein	0.927	0.928	0.923	0.936	0.944	0.930	0.932	0.929	0.934	0.0026	**
Casein/True Protein	0.841	0.829	0.829	0.823	0.815	0.826	0.834	0.828	0.831	0.0048	NS
Casein/Protein	0.777	0.771	0.766	0.772	0.768	0.768	0.774	0.770	0.776	0.0046	NS

S Interaction - significance of interaction

Restricted feeding reduced CP, TP and Casein by 1 - 2.7 g/kg or 4-7.5% in E and M, but not L, the greatest effects being between R & F. The content of all three components increased as lactation progressed but the interactions between the treatment and stage of lactation were significant ($P<0.01$ for CP and TP, and $P<0.05$ for Casein).

In E and M, but not L the contents of NCN, NPN and urea N were highest for treatment F. This was not reflected in consistently lower TP:CP, Casein:TP or whey:casein ratios as both CP and TP contents for F were higher than for S or R.

TP made up 92-94% of the protein and casein, 81-84% of TP, so while there were significant interactions, differences between the treatments in absolute terms, were small.

The content of the two protein fractions that form part of the non-casein or whey protein, bovine serum albumin (BSA) and total immunoglobulin (IgG) was lowest for R in E, but not M or L. Contents of both increased as lactation progressed.

In general where a treatment affected the crude protein content of milk, comparable changes occurred in the other N components. For example, in E lactation R reduced the CP content of milk relative to that of F. Also reduced were the contents of TP, casein, NCN, NPN, urea, BSA and total IgG. As a result there were only small absolute changes in the TP:CP, casein:TP and whey: casein ratios.

DISCUSSION

These results demonstrate the effects of severe pasture restriction and the effect of a supplement comprising approximately 30% of the diet, on a range of nitrogen components in milk at different stages of lactation. Previous reviews (Bryant 1979, Kolver and Bryant 1993) have reported on contents of fat, protein or solids-not-fat but have not included detailed milk protein components. This may be appropriate for farmers in Australasia who are paid according to the amount of milk produced and the contents of fat and protein, but not for processors. For example, processors producing butter require a milk supply containing a high concentration of milk fat; for cheese, a high content of casein, for nutritional supplements, a high content of whey proteins.

The results indicate that type and amount of diet affected milk components in early and mid lactation but generally not late lactation. Bryant (1979) also concluded that effects of diet manipulation on milk fat and protein content was greater in early than in late lactation. The effects reported here were small in absolute terms and are unlikely to account for the large differences that occurred between the 14 experiments reviewed by Bryant (1979). Kolver and Bryant (1993) also argued that level of feeding did not account for differences in protein content of milk that exists between farms producing milk of the same milkfat content. The conclusion of both these reviews, supported here, is that there is currently limited opportunity for the NZ dairy farmer to manipulate the composition of the N components in milk by means of diet. Sutton and Morant (1989) also concluded that opportunities for modifying or increasing milk protein concentration is severely limited. It is clearly unlikely that the processor could afford to reward those farm operators attempting to produce milk of a desired nitrogen component content by manipulation of the composition of the diet or level of feeding.

Where a treatment affected the crude protein content of milk, similar effects were generally reflected in the other nitrogen components. The importance of this is that the costs of the suite of analyses used here, together with the analysis of individual whey proteins is approximately $300/sample. It argues strongly against the indiscriminate application of the suite of analyses used here to studies of the effects of nutritional farm management practices on milk characteristics.

The efficiency of the identical twins used in this work and the precision of the analytical assays were such that the 18 sets used were the equivalent of using up to 900 unrelated cows depending on the nitrogen component and the stage of lactation. This undoubtedly accounts for why many differences were statistically significant, but of doubtful biological significance.

The results emphasise that farm operators are more likely to achieve maximum profitability through yield of milksolids from their farms, rather that yield of an individual milk constituents.

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