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PROTEIN DIGESTION AND UTILIZATION BY DAIRY COWS

J.D. OLDHAM, J.D. SUTTON and A.B. McALLAN

National Institute for Research in Dairying, Shinfield, Reading RG2 9AT

Proposals for changes in protein requirement systems for ruminants (exemplified by Roy *et al.,* 1977) are likely to have profound effects on the choice of rations for dairy cows. Central features of the proposed systems are that rates of animal production can be related to requirements for amino acid N entering the small intestine and that amino acid N supply to the intestines can be predicted from energy intake and characteristics of food N. These concepts have gained widespread acceptance but there are few supporting data for dairy cows either on quantitative N transformations in the rumen or, more markedly, on the relationship between amino acid N (AAN) flow to the intestines and milk protein yield. These experiments were designed to shed light on both these areas, but in particular on the quantitative relationship between duodenal AAN supply and milk protein production.

Methods

Four rations were used. They were designated 60B, 60M, 90B and 90M and were composed of concentrate mixes containing either rolled barley (B) or ground maize (M) as the major component, and were fed with hay in the ratios concentrates: hay of 60:40(60) or 90:10(90). The diets were formulated to provide equal amounts of digestible energy (DE) and crude protein (CP) (table 1). All of the experimental animals were mature Friesian cows.

Experiment 1 was designed to measure duodenal nutrient supply. Three cows were each fitted with a rumen cannula and a re-entrant duodenal cannula sited approximately 10 cm distal to the pylorus, but anterior to the entry of bile and pancreatic secretions. Each cow received each ration. Treatment periods started 6-8 weeks post-partum and lasted 6 weeks. In the last two weeks digesta were collected and sampled (2 1/2%) continuously for 72 h and a total collection of faeces was made for 8 days. Samples of rumen liquor were taken to isolate rumen bacteria by centrifugation. The microbial N content of duodenal samples was estimated by reference to the ratios of RNA:N and α-ε-diaminopimelic acid (DAPA):N in duodenal samples compared with those of isolated rumen bacteria. Allowance for food RNA contamination of duodenal samples was made as suggested by Smith *et al.,* (1978). The measured rate of digesta flow was not adjusted for recovery of indigestible markers (Sutton *et al.,* 1976).

Experiment 2 was designed to measure milk yield, milk composition and liveweight change in intact animals fed the same amounts of the diets used in Experiment 1. Sixteen cows in four groups of four were used in a continuous treatment design experiment for 12 weeks starting 7-8 weeks post-partum. For the first 7-8 weeks of lactation all cows received the same control ration. Milk yields in the last three weeks of this period were used to adjust milk yields in the treatment period by covariance. A total collection of faeces was made from each cow for eight days during the treatment period. Milk samples were taken from each cow for four consecutive milkings each week and were bulked in proportion to yield for analysis. The cows were weighed twice weekly.

Differences between treatment means were compared by analysis of variance.

Results

Experiment 1

There were differences in N and DE intakes between treatments (table 2), but these

Table 1. — Composition (g/kg) of concentrates and amounts of hay and concentrates offered (kg/d) in Experiments 1 and 2

Ration	60B	60M	90B	90M
Concentrate composition (g/kg)				
Rolled barley	820	—	870	—
Ground maize	—	780	—	830
Soyabean meal	160	200	110	150
Vitamin/mineral supplements	20	20	20	20
Daily allocation (kg)				
Concentrates	9	12.6	9	12.6
Hay	6	1.4	6	1.4

Table 2. — Intakes of N and DE, the passage of non-ammonia-N (NAN) and microbial N to the duodenum and OM digestion in the rumen of cannulated cows fed rations 60B, 60M, 90B and 90M. (Values are means for 3 cows)

Ration	60B	60M	90B	90M	s.e. of difference
N intake (g/d)	286	291	269	281	18.6
DE intake (MJ/d)	157[ab]	155[ab]	161[a]	149[b]	5.6
Duodenal flow of:					
NAN (g/d)	277[ab]	263[ab]	308[a]	244[b]	19.0
Microbial N (RNA) (g/d)	237[a]	173[b]	226[a]	104[c]	14.5
Microbial N (DAPA) (g/d)	216[a]	136[b]	194[a]	70[c]	15.0
Apparent digestion of OM in rumen (kg/d)	6.38 [a]	6.20 [a]	6.31[a]	5.29 [b]	0.42
Daily milk yield (kg/d)	14.3	14.2	16.9	16.7	3.0

Means which do not share the same superscript differ significantly ($P<0.05$).

Table 3. — Daily intakes of N and DE, mean daily milk and milk protein (N × 6.38) yields and liveweight change in intact cows fed rations 60B, 60M, 90B and 90M

Ration	60B	60M	90B	90M	s.e. of difference
N intake (g/d)	315[a]	295[ab]	287[b]	273[b]	12.9
DE intake (MJ/d)	157	158	164	158	3.1
Milk yield (kg/d)	16.3 [b]	18.6 [ab]	20.6[a]	15.8 [b]	1.9
Milk protein yield (g/d)	511[b]	559[ab]	617[a]	535[ab]	46
Liveweight change (kg/d)	−0.03 [ab]	−0.11 [b]	+0.34 [a]	+0.47 [a]	0.19

Means which do not share the same superscript differ significantly ($P<0.05$).

were small. Flow of non-ammonia N (NAN) to the duodenum was less than N intake for 60B, 60M and 90M but not for 90B. Duodenal NAN was greater with ration 90B than 90M ($P<0.01$) but otherwise differences were non-significant.

Microbial N flow to the duodenum was always higher if RNA rather than DAPA was used as microbial marker. If this difference represents protozoal N then 9-14% of microbial N was protozoal with barley diets but 21-23% with maize diets. With either marker, microbial N flow was significantly less ($P<0.01$) with ground maize compared with rolled barley rations. There was a significant difference ($P<0.01$) in microbial N flow between the two maize rations.

The amount of organic matter (OM) apparently digested in the rumen was significantly reduced ($P<0.05$) when ration 90M was fed.

Experiment 2

As with Experiment 1, there were differences in both N and DE intake between treatments (table 3) but these were relatively small.

Milk and milk protein yields were greatest with 90B. Cows fed 60% concentrate rations lost liveweight, whereas those fed 90% concentrate gained in weight.

Discussion

The observed differences in duodenal microbial N flow suggest that the N in these rations was fermented in the rumen to quite different extents. Net effects on duodenal NAN flow were however, relatively small.

For three of the rations (60B, 60M and 90B) the ratios g microbial N passing to the duodenum:kg OM apparently digested in the rumen were in the range 21-38. This range brackets the value of 30 chosen by Roy *et al.,* (1977) as an average of values reported in the literature, mainly from experiments with sheep. This ratio was lower for 90M (13 using DAPA, 19 using RNA as marker) and was generally lower for the maize compared with the barley rations. The reasons for these differences are likely to be complex but the magnitude of the values does not support the hypothesis that this ratio may be higher in cows at moderate to high levels of food intake.

As N and DE intakes were similar between experiments the digestion and production data can be compared. Duodenal AAN excluding methionine, cyst(e)ine and tryptophan, was 0.64-0.66 of NAN for each ration. The correct ratio of AAN:NAN was probably close to 0.7. A number of assumptions are necessary to compare duodenal NAN supply to total N utilization. These are: that milk N contains 95% protein N; that the protein content of liveweight change is 15%; and that maintenance needs for AAN $\times$ 6.25 are 60 g/day. Applying these to data in tables 2 and 3 yields the following:

Ration	60B	60M	90B	90M
Duodenal AAN				
$\times$ 6.25 g/d = (y)	1286	1231	1429	1138
† Productive protein = (x)	542	574	698	639
x $\div$ y	0.42	0.47	0.49	0.56

† = (milk protein + liveweight protein gain + maintenance).

Thus allowing for the protein content of liveweight change and for maintenance, between 0.42 and 0.56 of duodenal AAN was used productively. Assuming the efficiency of absorption of AAN in the small intestine to be 0.7 (Roy *et al.,* 1977) the efficiency of use of absorbed protein (EPU, Oldham 1978) was 0.60, 0.67, 0.70 and 0.80 for 60B, 60M, 90B and 90M respectively.

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