The effects of intraruminal infusions of urea, casein, glucose syrup and a mixture of casein and glucose syrup on N digestion in the rumen of cattle receiving grass silage diets

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Summary

1. In an incomplets 5 x 5 Latin square experiment four cattle were given grass silage in two meals per d to satisfy 1.15 maintenance energy requirements. In addition, water or casein (21 *g* nitrogen (N) and 0.17*kg* organic matter (OM)/d) or urea (28 *g* N/d) or a glucose syrup (0.8*kg* OM/d) or casein and glucose syrup (17gN and 0.93*kg* OM/d) were infused intraruminally at a constant rate.

2. A 24h collection of duodenal digesta was made using chromic oxide for flow estimation and ^{35}S as a marker of microbial N entering the small intestine. Samples of rumen fluid were also taken for estimation of rumen pH, ammonia-N and volatile fatty acid concentration.

3. The intraruminal infusions had no significant effects upon rumen pH, volatile fatty acid concentrations or their molar proportions. Infusion of either casein (C) or urea (U) significantly ($P<0.05$) increased rumen ammonia-N concentrations whereas infusions of either glucose syrup (G) or of casein and glucose syrup together (CG) lowered rumen ammonia-N concentrations.

4. Infusions of casein or of urea had no significant effect upon the quantities of OM, acid detergent fibre (ADF) or N-constituents which entered the small intestine.

5. Infusions of glucose syrup or casein and glucose syrup increased the quantities of OM (G, $P<0.05$; CG, $P<0.01$), ADF (CG, $P<0.05$) non-ammonia-N (G, $P<0.05$; CG, $P<0.01$), amino acid N (G, $P<0.05$; CG, $P<0.01$) and microbial N (G, $P<0.05$; CG, $P<0.01$) which entered the small intestine.

6. The efficiency of rumen microbial N synthesis was unchanged by the infusion of casein, urea or glucose syrup ($P>0.05$) but increased significantly ($P<0.05$) when casein and glucose syrup were infused.

During ensilage, the soluble carbohydrates present in grass are fermented to lactic acid and volatile fatty acids by anaerobic bacteria. Extensive proteolysis of the herbage protein also takes place chiefly as a result of the activity of plant proteases (McDonald, 1981). Thus when silage is given to ruminant livestock the major carbohydrate substrates available for rumen fermentation are the slowly fermented plant cell walls whilst most of the nitrogenous substrates available for rumen microbial synthesis are soluble and are present in silage in the form of non-protein nitrogen (N) eg ammonia and amino acids. The efficiency of microbial N synthesis in the rumen in animals given silage is markedly lower than the value of 32g N/kg organic matter (OM) apparently digested in the rumen (OMADR) adopted by the Agricultural Research Council (ARC, 1984), with most values being in the range 25～30g N/kg OMADR (see e.g. Thomson et al. 1981; Chamberlain et al. 1982; Rooke et al. 1983a).

Supplementation of grass silage with barley has proved largely ineffective in stimulating the efficiency of rumen microbial N synthesis (Thomas et al. 1980; Rooke et al. 1985a) whereas consistent responses have been obtained by supplementing silage fed to cattle with soya-been meal (Brett et al. 1979; Rooke et al. 1983b. 1985a), although not with sheep (Siddons et al. 1979). The experiment reported here was designed to establish whether these responses to soya-bean meal supplementation were a response to the release in the rumen of additional ammonia-N or of amino acids and peptides; a further objective was to investigate whether a rapidly fermentible soluble carbohydrate would prove effective in stimulating microbial N synthesis in the rumen. Cattle fed grass silage were supplemented intraruminal infusions of water (control) or urea, casein, glucose syrup, or casein and glucose syrup. The effects of these infusions upon the entry of microbial N, undegraded feed N and other constituents into the small intestine were measured.

EXPERIMENTAL

Animals

The four female Jersey cattle, aged between 4 and 5 years, used for the experiment had mean (with SE) weights of 409 (21.5) kg at the beginning of the experiment. Each animal was equipped with a rumen cannula and a re-entrant cannula in the proximal duodenum (McMeniman & Armstrong, 1979).

Diets and experimental procedure

The animals were fed grass silage throughout the experiment and in addition each animal was infused intraruminally with each of five different solutions in turn according to an incomplete 5 x 5 Latin square experimental design.

The grass silage was prepared from a first cut of predominantly perennial ryegrass (Lolium perenne) containing some white clover (Trifolium repens), harvested with a precision-chop forage harvester on 7 June 1983. The grass was wilted for 24h and ensiled by means of an Eberhard Silopresse (Benedict Agricultural Ltd, London) with the application of an additive containing 850g formic acid/kg (Add-F, BP Nutrition UK Ltd). The silo was opened after 210 days and from then on silage was removed at weekly intervals, weighed and stored in tightly closed plastic bags at room temperature. The composition of the silage is given in Table 1.

Table 1. The chemical composition (g/kg dry matter) of the silage

pH	3.8
Dry Matter (g/kg)*	229
Organic matter	934
Acid detergent fibre	364
Neutral detergent fibre	738
Water soluble carbohydrate	61
Total nitrogen	18.4
Amino acid nitrogen	12.5
Ammonia nitrogen	1.2
Formic acid	22
Acetic acid	19
Lactic acid	111
Ethanol	69

* Determined by toluene distillation.

The silage was offered to each animal twice daily in equal amounts at 08.00 and 16.00h throughout the experiment. The amount of silage offered supplied sufficient metaboloizable energy to provide 1.15 times the maintenance energy requirements of each animal, calculated from the liveweight of the animal at the start of the experiment (Ministry of Agriculture, Fisheries and Food, 1975). In the event, it was necessary to reduce silage intake to 1.0 times maintenance energy requirements in order to avoid silage refusals when glucose syrup alone or casein and glucose syrup together were infused (see below). Water and mineralized salt licks were freely available throughout the experiment and 2 x 10g chromic oxide impregnated paper/d was administered to each animal after each feed.

Each experimental period was 21d long and consisted of a 14d infusion period followed by a 7d rest period. The five different intra-ruminal infusions consisted of water (W); casein (Technical grade, Sigma Chemical Co Ltd, 70g casein/kg infusate, C); urea (General Purpose Reagent, BDH Ltd, 35g urea/kg infusate, U); glucose syrup (42DE, CPC Ltd, Trafford Park, Manchester, 530g glucose syrup/kg infusate, G) and casein and glucose syrup (35g casein and 265g glucose syrup/kg infusate, CG). The glucose syrup contained (g/kg total carbohydrate) glucose (170), maltose (130), maltotriose–maltoheptose (420) and oligosaccharides of chain length greater than 7 (280). The intention was to maintain infusion rates of 0.11/h for infusates, W, C, U and G and 0.21/h for infusate CG; in practice there were some deviations from these rates but the exact amounts of each infusate infused were recorded daily. In addition to the nutrients included in the infusates, 2.5mC $Na_2^{35}SO_4$ was added to each infusate at 09.00g on day 12 of each infusion period and this infusion of ^{35}S was maintained until the completion of the 24h collection of duodenal digesta. On the final day of each infusion period (day 14), beginning at 08.00 h a 24h complete collection of duodenal digesta was made from each animal. In addition 16 samples of rumen fluid were obtained at 1.5h intervals from 09.00h on day 14. Details of the sampling procedure and of the preparation of a duodenal microbial fraction have been given by Rooke et al. (1985b).

Analytical procedures

The procedures used in the analysis of the silage, infusates, rumen fluid, duodenal digesta and the duodenal microbial samples have been described (Rooke et al. 1985b). Additionally, the ethanol content of the silage was determined according to Böttcher (1982) and the free glucose plus α-linked glucose polymer contents of the infusates and duodenal digesta samples were determined according to MacRae & Armstrong (1969).

Calculation of results

Flows of digesta dry matter (DM) entering the small intestine were corrected for complete recovery of chromic oxide administered daily. The intake of soluble carbohydrate (CHO) was calculated as the sum of silage water soluble carbohydrate (determined by the anthrone method) and infused carbohydrate (determined as free glucose plus α linked glucose polymers); the soluble CHO content of duodenal digesta was determined as the free glucose plus α linked glucose polymers.

Statistical analysis

Analysis of variance was carried out on the data according to an incomplete Latin square design using a least squares procedure. Two sets of experimental values were missing from the data due to the removal of two different animals from two different experimental periods for reasons not connected with the diets being fed i.e. leakage of digesta from the duodenal cannula in one case and accidental temporary disconnection of the duodenal cannula and loss of digesta in the other case. Differences between each infusion and the control (water) infusion were determined using Dunnett's test (Dunnett, 1955).

RESULTS

Infusing different nutrients had no significant

Table 2. Mean value for pH and for the concentrations of ammonia-nitrogen (mg/l) and volatile fatty acid (mmol/l) in the rumen fluid of cattle given diets of grass silage and five different intraruminal infusions.

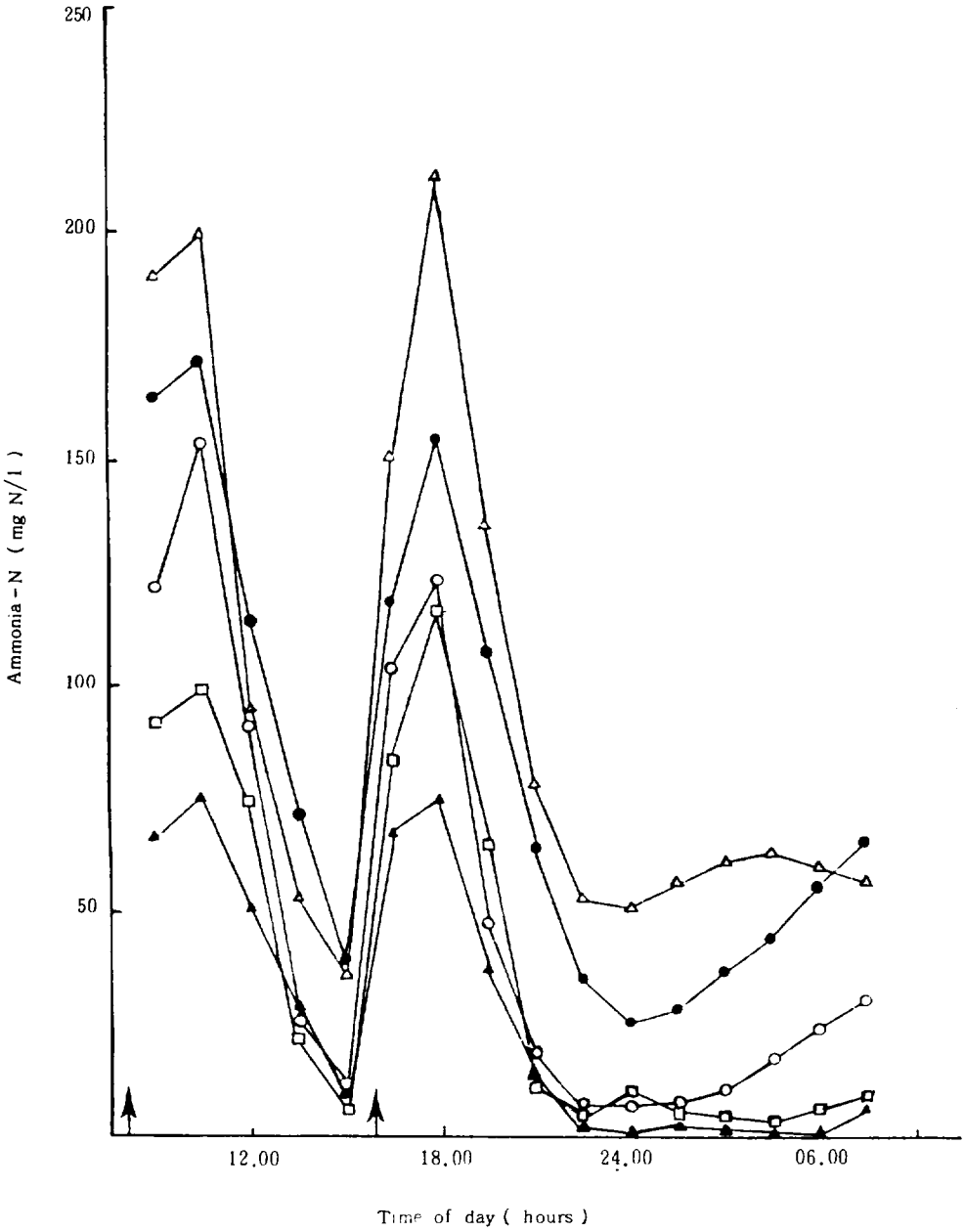
(The molar proportions of individual fatty acids (mmol acid/mol total volatile fatty acids) are also given)

	Infusions*						Statistical Significance of infusions†	
	W	C	U	G	CG	SE	U	C
pH	6.8	6.8	6.8	6.8	6.7	0.02	NS	NS
Ammonia-N	51	98	82	28	39	11.1	*	*
Volatile fatty acids								
Total	67.3	67.3	65.3	71.4	66.0	2.96	NS	NS
Acetic	682	678	661	687	666	7.6	NS	NS
Propionic	177	177	178	179	187	7.5	NS	NS
iso-butyric	13	13	16	10	9	1.0	NS	NS
n-Butyric	82	83	83	86	96	3.9	NS	NS
iso-Valeric	30	31	41	22	22	4.2	NS	NS
n-Valeric	17	18	21	16	19	0.7	NS	NS

* Infusions; W, water; C, Casein; U, urea; G, glucose syrup; CG, casein plus glucose syrup. For details see p.

† No significant effects were observed for infusions G and CG.

Figure 1. Daily variations in rumen ammonia-nitrogen concentrations of cattle given grass silage diets in two meals per d (↑ times of feeding) supplemented with intraruminal infusions of water (○), casein (●), urea (△), glucose syrup (▲) or casein and glucose syrup (□). For details see p. Mean values for four observations are given for water, casein and urea infusions and for three observations for glucose syrup and casein and glucose syrup infusions.



effects on mean rumen pH, volatile fatty acid concentrations or molar proportions of individual fatty acids (Table 2). Infusing either casein or urea significantly ($P < 0.05$) increased rumen ammonia—N concentrations when compared with the infusion of water alone. In addition, although the

Table 3. The mean quantities (kg/24 h) of organic matter (OM), soluble carbohydrate (CHO) and acid detergent fibre (ADF) consumed by the cattle, infused intraruminally and entering the small intestine.

(The quantities of OM, soluble CHO and ADF entering the small intestine daily are also expressed as a proportion g/g of OM, soluble CHO or ADF intake)

	Infusion*						Statistical Significance of infusions†	
	W	C	U	G	CG	SE	G	CG
OM intake from								
Silage	4.78	4.77	4.94	4.29	4.40	-	-	-
Infusion	-	0.17	0.06	0.87	0.93	-	-	-
Total	4.78	4.94	5.00	5.16	5.33	-	-	-
Soluble CHO intake from								
Silage	0.32	0.28	0.28	0.25	0.29	-	-	-
Infusion	-	-	-	0.75	0.64	-	-	-
Total	0.32	0.28	0.28	1.00	0.93	-	-	-
ADF intake from								
Silage	1.84	1.87	1.79	1.67	1.68	-	-	-
Entering small intestine OM								
(kg/24h)	1.66	1.80	1.76	1.99	2.42	0.080	*	**
(g/g intake)	0.35	0.36	0.38	0.39	0.46	0.023	NS	*
Soluble CHO								
(kg/24 h)	0.04	0.05	0.04	0.08	0.09	0.003	**	**
(g/g intake)	0.12	0.18	0.14	0.08	0.10	0.023	NS	NS
ADF								
(kg/24 h)	0.30	0.31	0.32	0.35	0.41	0.018	NS	*
(g/g intake)	0.16	0.17	0.18	0.21	0.24	0.011	*	**

* Infusions: W, water; C, casein; U, urea; G, glucose syrup; CG, Casein plus glucose syrup. For details see p.

† No significant effects were observed for U and C infusions.

differences were not significant, infusion of casein and glucose syrup together or of glucose syrup alone reduced ammonia—N concentrations in comparison with the water infusion with the lowest mean values for ammonia—N being observed when glucose syrup alone was infused.

The changes in rumen ammonia—N concentrations throughout the day are shown in Fig.1. The significant increase observed in ammonia—N concentrations (Table 2) when casein or urea were infused was apparent at all sampling times as were the reductions in ammonia—N concentrations observed when glucose syrup alone or glucose syrup plus casein were infused. Indeed, when glucose syrup alone was infused mean ammonia—N concentrations observed between 22.30 and 06.00 h were less than 5㎎ ammonia—N/l.

The daily intakes of organic matter (OM),

Table 4. The mean quantities of total (TN) and amino acid nitrogen (AAN) consumed (g/24 h) by the cattle, infused intraruminally and the quantities (g/24 h) of non-ammonia nitrogen (NAN) and AAN entering the small intestine.

(The quantities of NAN and AAN entering the small intestine daily are also expressed as a proportion of the quantity of TN or AAN ingested)

	Infusion+						Statistical Significance of Infusions†		
	W	C	U	C	CG	SE	U	G	C
TN intake from									
Silage	94	95	90	86	86	-	-	-	-
Infusion	-	21	28	-	17	-	-	-	-
Total	94	116	119	86	103	-	-	-	-
AAN intake from									
Silage	64	62	61	57	57	-	-	-	-
Infusion	-	18	-	-	14	-	-	-	-
Total	64	80	61	57	71	-	-	-	-
NAN entering small intestine									
g/24 h	89	94	91	106	139	4.1	NS	*	
g/gTN intake	0.94	0.81	0.76	1.24	1.35	0.050	*	**	
AAN entering small intestine									
g/24 h	61	68	63	75	94	2.7	NS	*	
g/gAAN intake	0.97	0.85	1.04	1.32	1.33	0.064	NS	*	

+ Infusions: W, water; C, casein; U, urea; G, glucose syrup; CG, casein plus glucose syrup. For details see p.

† No significant effects were observed for C infusion.

soluble CHO and acid detergent fibre (ADF) by the cattle, and the quantities of OM, soluble CHO and ADF entering the small intestine are shown in Table 3. Infusion of casein or urea had no significant effects upon the quantities of OM, soluble CHO or of ADF entering the small intestine daily.

However, infusion of glucose syrup or of glucose syrup and casein resulted in increases in the quantities of OM (G, $P<0.05$; CG, $P<0.01$) soluble CHO (G, $P<0.01$; CG, $P<0.01$) and of ADF (G, NS; CG, $P<0.05$) entering the small intestine. The increase in the amounts of soluble CHO entering the small intestine daily were quantitatively small; indeed when expressed as a proportion of the total soluble CHO intake, proportionately less soluble CHO entered the small intestine daily when glucose syrup was infused alone or together with casein. However, expressed as a proportion of total OM and ADF intake, the increases in OM (CG, $P<0.05$) and ADF (G, $P<0.05$; CG, $P<0.01$) entering the small intestine when glucose syrup or glucose syrup and casein were infused were significant; the increase in OM when glucose syrup alone was infused was non-significant. Thus, inclusion of casein in the glucose syrup infusion, gave rise to greater increases in the quantities of OM and ADF entering the small intestine than were observed with glucose syrup alone.

The quantities of total N (TN) and of amino acid N (AAN) ingested as silage TN and AAN and infused intra-ruminally are shown in Table 4. as are the quantities of non-ammonia N (NAN) and AAN entering the small intestine. Increasing TN intake by infusing urea or casein, and AAN intake by infusing casein, did not significantly change the quantities of NAN or of AAN entering the small intestine as compared with the infusion of water. Thus, when expressed as a proportion of TN intake, significantly smaller amounts of NAN entered the small intestine (g/gN intake) when urea ($P<0.05$) was infused. Infusion of glucose syrup increased the quantities of NAN and AAN entering the small intestine when expressed either as g/day (NAN and AAN, $P<0.05$) or g/gN (or AAN) intake (NAN, $P<0.01$; AAN, $P<0.05$). Addition of casein to the glucose syrup infusion resulted in increases in the quantities of NAN and AAN entering the small intestine when compared with the water infusion (g NAN or AAN/day $P<0.01$; g/gN (or AAN) intake, NAN, $P<0.01$; AAN, $P<0.05$) which were markedly greater in magnitude than those observed when glucose syrup alone was infused.

Table 5. shows the quantities of microbial N and undegraded feed (plus endogenous) N entering the small intestine. Infusing urea or casein did not significantly change the quantities of microbial N or of feed N which entered the small intestine as compared with the quantities entering the small intestine when water was infused. There were no significant changes in the apparent efficiency of microbial N synthesis when urea or casein were infused. The apparent degradability of feed N was significantly increased when casein ($P<0.05$) but not urea was infused. Infusion of glucose syrup significantly ($P<0.05$) increased the microbial N entering the small intestine, compared with when water was infused. However, the increase in the efficiency of microbial N synthesis when glucose syrup was infused was not significant. Addition of casein to the glucose syrup resulted in increases in microbial N entering the small intestine ($P<0.01$) and in the efficiency of microbial N synthesis ($P<0.05$) compared with water, which again were markedly greater than the increase observed when glucose syrup alone was infused. The infu-

Table 5. Mean quantities (g/24 h) of microbial total nitrogen (TN) entering the small intestine and the apparent efficiency of microbial N synthesis in the rumen (gN/kg organic matter apparently digested in the rumen)

(Also shown are values for the apparent quantities (g/24 h) of feed non-ammonia nitrogen (NAN) entering the small intestine, together with values for the apparent degradability of feed total N within the rumen)

	Infusion+						Statistical Significance of infusions†		
	W	C	U	G	CG	SE	C	G	CG
Microbial TN entering small intestine	63	75	68	81	109	4.5	NS	*	**
Efficiency of microbial TN synthesis	22	25	25	27	38	2.7	NS	NS	*
Feed N entering small intestine+++	22	19	24	23	28	2.4	NS	NS	NS
Apparent feed TN degradability	0.76	0.83	0.80	0.73	0.72	0.019	*	NS	NS

+ Infusions; W, water; C, casein; U, urea; G, glucose syrup; CG, casein plus glucose syrup. For details see p.

+++ Includes endogenous N secretions. Values for degradability of feed nitrogen calculated from the difference between total N intake and duodenal (NAN−microbial TN).

† No significant effects of U infusion.

sion of glucose syrup alone or in conjuction with casein did not significantly alter the quantities of feed (plus endogenous) N entering the small intestine or the apparent degradability of feed N.

DISCUSSION

Digestion of silage

When silage was fed alone the efficiency of microbial N synthesis in the rumen observed in this experiment 22 gN/kg OMADR was within the range of values previously observed with cattle (20～30 gN/kg OMADR; Brett et al. 1979; Thomson et al. 1981; Rooke et al. 1982, 1983a, b, 1985a). The extensive fermentation of OM within the rumen and the marked diurnal fluctuations in rumen ammonia−N concentrations as a result of twice daily feeding were also in line with previous observations. The low efficiencies of rumen microbial N synthesis when ruminants were fed silage have been variously related to low yields of ATP/kg OMADR because of the presence of fermentation end products in the si-

lage OM Thomas, 1982), (ii) to poor synchronization of the rates of N and energy release from silage leading to a low efficiency of N capture by the rumen micro-organisms and consequent losses of ammonia across the rumen wall (Siddone et al. 1985) or (iii) to the form in which rumen degradable N is present in silage i.e. as amino acids and ammonia (Rooke et al. 1985 a).

Infusion of casein or urea

Previous experiments (Brett et al. 1979; Rooke et al. 1983 b, 1985 a) showed that the stimulation in the efficiency of rumen microbial N synthesis observed when silage was supplemented with soya-bean meal was associated with increases in rumen ammonia—N concentrations such that the values of less than 50mgN/l observed between feeds when soya—been meal was not present were elevated above 50mgN/l when the meal was included in the diet. In the present experiment, urea or casein were continuously infused intra—ruminally in an attempt to clarify the basis of the stimulation of rumen microbial N synthesis obtained with soya—been meal supplementation. Urea was infused to determine whether the stimulation resulted from an improved synchronization of the rates of release in the rumen of ammonia and energy, whereas casein was infused to determine whether the supply of amino acids and peptides from degraded protein—N was important. As expected urea and casein improved N supply to the rumen micro-organisms as both infusions elevated rumen ammonia—N concentrations over the 24 h sampling period (see Fig.1). However, only small and non-significant increases in the quantity of microbial N synthesized and in the efficiency of microbial N synthesis in the rumen were observed. These results indicate that it was not a shortage of rumen ammonia—N per se that was limiting the efficiency of rumen microbial synthesis when silage was fed. Furthermore, the failure of casein to stimulate microbial N synthesis suggested that a supply of additional amino acid—N or peptide—N was not an important limiting factor. The present experiment, did not therefore provide any explanation for the stimulation of microbial N synthesis by soya-been meal observed previously.

Infusion of glucose syrup

Infusion of glucose syrup alone reduced rumen ammonia—N concentrations throughout the 24 h sampling period to such an extent that between 24.00 and −6.00 h rumen ammonia—N concentrations were frequently below the limits of detection of the assay procedure used (<2mg N/l). Thus, the glucose syrup reduced ammonia—N concentrations markedly in agreement with Syrjala (1972) and the recent observations of Chamberlain et al. (1985). Rumen ammonia—N were also lower than in experiments where silage was supplemented with barley (Rooke et al. 1985a) again in agreement with the results of Syrjala (1972) and Chamberlain et al. (1985) where direct comparisons between starch and sucrose in reducing ammonia—N concentrations were made. The observed reduction in rumen ammonia-N concentration was accompanied by a 1.2 fold increase in the quantities of non-ammonia N which entered the small intestine daily in agreement with the results of Gill & Ulyatt (1977). As suggested by Gill & Ulyatt (1977) the increase in the quantities of non-ammonia N which entered the small intestine was mediated solely by an increase in the quantities of microbial N synthesized within the rumen. Chamberlain et al. (1985) have also suggested that the reduction in ammonia—N concentrations mediated by sucrose supplementation reflected increased microbial N synthesis within

the rumen. The results from this experiment therefore have confirmed experimentally the suggestions made by Gill & Ulyatt, 1977 and by Chamberlain et al. 1985.

The increase in the quantities of microbial N entering the small intestine when glucose syrup was infused was accompanied by only a small increase in the efficiency of rumen microbial N synthesis (22 to 27gN/kgOMADR). Since the mean rumen ammonia—N concentration when glucose syrup was infused was only 28mgN/l it is probable that ammonia supply was limiting microbial N synthesis, (see Miller, 1982). Addition of casein to the glucose syrup infusate resulted in mean rumen ammonia N concentration increasing from 28 to 39mg N/l with corresponding increases in both the quantities of microbial N synthesized and the efficiency of synthesis. Thus the supply of N or amino acids to the micro-organisms was apparently limiting microbial N synthesis when glucose syrup alone was infused; whether infusion of urea would have been as effective as casein is currently under investigation.

Thomson et al. (1981) calculated values for the ratio rumen degradable carbohydrate (DC) ; degradable N (DN) in calves fed grass silages and found that an increase in the ratio from 18 to 32 was associated with an increase in the apparent efficiency of capture of degraded N in the rumen from 65 to 95 % and an increase in efficiency of microbial N synthesis from 24 to 29gN/kg OM apparently digested in the rumen. In agreement with Thomson et al. (1981) infusion of glucose syrup increased DC: DN from 49 when water was infused to 57, the apparent efficiency of capture of degraded N in the rumen from 88 to 129 % and the efficiency of microbial N synthesis from 22 to 27 gN/kg OM apparently digested in the rumen. In contrast, however addition of casein to the glucose syrup reduced DC: DN from 57(G) to 46(CG) yet the apparent efficiency of capture of degraded N increased from 129 % to 145 % and the efficiency of microbial N synthesis from 27 to 38 gN/kg OM apparently digested in the rumen. This contrasting observation probably reflects the improved synchronization of supply of energy and of N for microbial synthesis and in part the well documented synergistic effect of supplying a mixture of structural and non-structural carbohydrate in the diet upon the efficiency of rumen microbial N synthesis (e.g. Offer et al. 1978; Mathers & Miller. 1981).

Calculation of the ratio DC: DN above also demonstrates the improved capture of degraded N within the rumen resulting from the infusion of glucose syrup alone or in conjuction with casein such that a net loss of N between the mouth and small intestine of 1.0 gN/kg OM intake when silage was fed alone was translated into net gains of 3.9 and 6.8 gN/kg OM intake when glucose syrup or glucose syrup and casein were infused intraruminally. The change from net loss to a net gain of N across the forestomachs as a result of carbohydrate infusion is in agreement with the concepts (Kennedy & Milligan. 1980) that (i) the transfer of endogenous urea to the rumen is inversely related to the rumen ammonia —N concentration, and (ii) that the addition of sucrose to the diet markedly increased the clearance of plasma urea to the rumen. The additional net gain of N across the forestomachs observed when casein and glucose syrup were infused might be caused by increased plasma urea concentrations as a result of catabolism of additional quantities of amino acids absorbed from the small intestine.

The results from this experiment have shown that in agreement with other workers (Syrjala, 1972, Gill & Ulyatt, 1977 Chamberlain et al.

1985) the utilisation of silage N for rumen microbial N synthesis is markedly improved by the provision of soluble carbohydrates for rumen fermentation. However, the practical advantages in improving animal performance through the use of soluble carbohydrates, may be limited to some extent by the reduction in the extent of fibre digestion which occurred within the rumen when soluble carbohydrate was infused in this experiment and the likely reductions in voluntary food intake of the silage caused by this inhibition of fibre digestion. In this experiment, silage intake had to be reduced to avoid refusals when glucose syrup was infused. Similarly, when England & Gill (1985) fed increasing amounts of sucrose to calves as a supplement to ad libitum silage, a progressive reduction in both the apparent digestibility of silage cellulose and in silage intake was observed.

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