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The demonstration by Milligan *et al.*, (1972) that glucosyl urea (GU) was degraded in the rumen more slowly than the individual components implied that the use of such ureides as dietary NPN sources might combine low toxicity with the provision of a controlled energy supply. We have taken particular interest in lactosyl urea (LU) and its preparation from whey.

Material and Methods

Preparation of pure LU was based on the method of Hynd (1926). Reaction time was shortened by using a higher temperature (70 °C). The method was also adapted to permit the preparation of high yields of LU in mixtures using whey (McAllan *et al.*, 1974), whey concentrate or permeate as starting material. A commercially prepared product (« Ewoplus », Astra-Ewos, Södertälje, Sweden) is available.

Metabolism of GU and LU was studied *in vitro* and *in vivo*. For *in vitro* experiments whole rumen contents (straining greatly reduced activity) were obtained prior to the morning feed from sheep or steers receiving a basal diet of barley, straw and urea before (unadapted) or after LU had been added to it for up to 30 d. Samples were added to the appropriate substrate in bicarbonate buffer at pH 6.8 and a dose of $^{32}P^{-}$ Phosphate added when required. The flasks were fitted with Bunsen valves, gassed with carbon dioxide and shaken at 39 °C for varying periods.

For *in vivo* experiments suitably cannulated sheep or steers were given the basal diet described above. At different periods either LU or free lactose and urea (L + U) were included with the diet together with polyethylene glycol (PEG) as a non-absorbable marker. Collection of rumen and sometimes abomasal digesta were made at different times after feeding.

Results and Discussion

When LU (or GU) were incubated with rumen contents from the unadapted animal, no release of bound nitrogen occurred but there appeared to be a slow cleavage of galactose from LU to yield GU (fig. 1a). When similar incubations were made with rumen contents from animals which had been given LU in their diet (about 20% of total N) for a period of at least 10 d, then both N and sugar were degraded. However, degradation still occurred much less rapidly than when L + U were added (fig. 1b). Ammonia concentrations remained considerably lower after LU than after L + U addition (5.2 and 12.5 mM res-

pectively after 1 h). The degree of adaptation remained essentially constant after 10 d supplementation with LU as long as the supplement was continued but disappeared rapidly (within 7 d) when it was stopped.

When LU was added to the rumen of sheep or steers, changes similar to those found *in vitro* occurred including slow conversion to GU. Changes in the extent of N release are exemplified in fig. 2 and show that even in the adapted animal, N release was much slower with LU than with L + U addition. Rate of disappearance of sugar was also much slower for LU than for L + U (c.f. fig. 1). For the unadapted animal recovery of bound urea at the abomasum was essentially complete but only GU was detected. As there were sometimes high concentrations of LU in the rumen degradation may have occurred in the omasum. After adaptation no more than 10% of bound urea entered the abomasum.

It was clear from the above results that in the adapted animal the pattern of LU metabolism in the rumen differed substantially from that of L + U.

Total ^{32}P incorporation has been used to assess microbial yield in rumen contents (Van Nevel and Demeyer, 1977). We have made similar assessments of ^{32}P incorporation but into bacterial nucleic acids. It was found that under the conditions used bacterial Total N: Nucleic acid-P ratios remained reasonably constant during incubations of up to 7 h. Estimates of microbial growth were

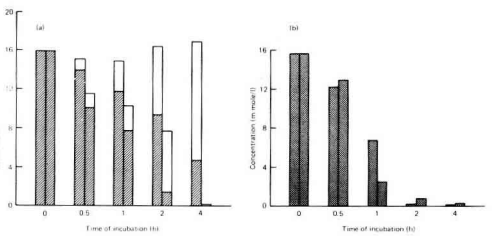

Fig. 1. — Changes in concentration of LU ▨, GU □ and lactose ⊡ in sheep rumen contents incubated with (a) LU and (b) L + U. The left and right columns of each pair were for contents from sheep unadapted and adapted to LU respectively.

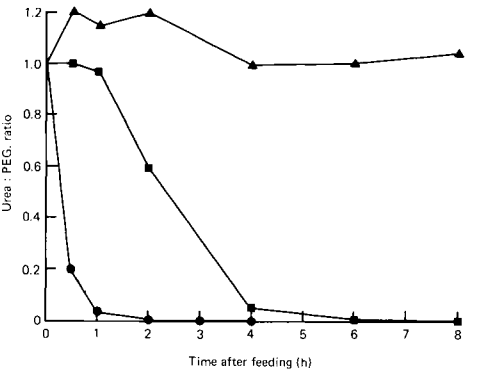

Fig. 2. — Changes in urea (free or bound): PEG ratios in the rumens of steers with time, after giving PEG with L + U (●) or LU to an unadapted (▲) or adapted (■) animal. Results are mean values for 3 steers.

Table 1. — Estimates of microbial N incorporation and sugar (free and bound) disappearance during different periods of incubating rumen contents with LU or L + U

Substrate	Incubn. Time (h)	N incorpn. (mg) A	Sugar dissap. (g) B	A/B
LU	0 - 1	25	1.5	17
	1 - 2	43	0.7	61
	0 - 2	68	2.2	31
L + U	0 - 1	31	2.1	15
	1 - 2	26	0.1	260
	0 - 2	57	2.2	26

Results corrected for growth without added substrate.

made in this way in samples of rumen contents in which excess degradable nitrogen was present but energy was limiting. Comparisons when LU rather than L + U were added to the samples showed consistently that there was an initial period in which growth was faster for L + U but that this relation was later reversed. The effect is exemplified by the results in table 1. There is evidence that the bacteria accumulated storage polysaccharide during early growth particularly in the presence of lactose. This energy source presumably supported subsequent growth even when the lactose substrate had been almost completely removed (table 1).

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