VOLATILE FATTY ACIDS PRODUCED BY A SHEEP FED PURE CELLULOSE AS SOLE CARBOHYDRATE IN ITS DIET*

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The quantities of volatile fatty acids (VFA) formed from cellulose in the rumen, and their relation to the amount of cellulose digested, have not previously been determined *in vivo*. We have recently maintained a sheep on a diet of pure cellulose (500 g), gluten (50 g), and inorganic salts (6–20 g) for a period of several months, and have measured VFA production in the rumen along with the extent of digestion of the cellulose in the animal. A characteristic of the digestion was the formation of large proportions (34–42%) of propionic acid, in contrast to the proportions found in the rumen of sheep at pasture, or fed on dry roughages — where propionic acid, though variable, usually constitutes only about 20% of the total VFA. The findings are summarized in Table 1.

Table 1

Digestion of cellulose* and production of VFA

	Series 1 (8–10 June)			Series 2 (24–25 August)	
Day No.	1	2	3	1	2
Cellulose consumed (g)	364	372	446	353	310
VFA (moles/24 hr)†	3·02	2·95	3·03	2·83	2·70
VFA (moles/kg dry matter fed)	7·3	7·1	6·1	6·8	7·2
VFA, molar proportions					
Acetic acid (%)	52	50	50	56	57
Propionic acid (%)	40	42	42	34	35
Butyric acid (%)‡	8	8	8	10	8

* Digestion of cellulose in 15-day collection period (including series 2) = 84%.

† Determined by the isotope-dilution method of Weller *et al.* (1967).

‡ Includes higher VFA.

The early work of Elsden (1945) and Gray and Pilgrim (1952) using rumen microorganisms *in vitro* showed that cellulose and hemicellulose were fermented and yielded a large proportion of propionic acid, and although it is now realized that the conditions then used were in some respects far removed from those existing in the rumen, the similarity between our *in vivo* and *in vitro* findings is striking.

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The rate of production of VFA — approximately 6–7 moles/kg dry matter ingested — was greater than we have usually found for dry roughages (Gray *et al.* 1967) and this must be attributed to the high digestibility (84%) of the cellulose.

Others have maintained ruminants on purified mixtures of cellulose, starch, and sugars, but no quantitative data relating products of fermentation to substrate digested have previously been reported from *in vivo* studies, and thus, although our data are derived from only one sheep, they provide the first opportunity to consider the amounts of individual acids formed from cellulose *in vivo* in the light of present views on the metabolic pathways involved in the rumen fermentation and the implied stoichiometric relationships (Hungate 1966). Using Hungate's formulae, the fermentation of 1 mole of hexose (as cellulose) should yield 1·83 moles VFA + 0·92 mole CO_2 + 0·43 mole CH_4, in order to give the particular proportions of individual acids we observed (series 2, Table 1). In fact we obtained a yield of 1·56–1·68 moles VFA from 1 mole of "hexose" digested, and of this only a very small part could have been derived from the gluten fed. The deficit between 1·62 and 1·83 moles VFA, representing about 11·5% of the latter, should be accounted for by production of VFA in another part of the alimentary tract, viz. the large intestine, and by any assimilation into the proliferating microorganisms of VFA or other products of cellulose breakdown. Hungate summarizes evidence from a number of sources which indicate that the weight of microbial cells formed in the rumen fermentation is at least 10% of the substrate fermented. On this basis our findings for the cellulose–gluten diet would account for practically all the digestion of cellulose, leaving room for only a very small production of VFA in the large intestine.

In view of the different roles the individual acids may have in the intermediary metabolism of ruminants, an explanation for the marked difference in products formed from dry roughages on the one hand, and from a cellulose diet on the other, is needed, since it could contribute useful information leading to some measure of control over the direction of the rumen fermentation. As the cellulose was fed as paper, its degree of polymerization was therefore probably considerably less than that of natural plant cellulose. Whether this would affect end-products as well as rate of digestion is not known.

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