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CHEWING AND THE PHYSICAL BREAKDOWN OF FEED IN SHEEP

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We are undertaking a quantitative study of the physical breakdown of feed during its digestion by sheep (Reid *et al.,* 1977), partly to understand more fully how digestion is controlled, partly to define better the physical attributes of feed which are important in determining its nutritive value.

The main processes contributing to the physical breakdown of ingested feed - chewing, microbial fermentation and mechanical detrition within the reticulo-rumen (ReRu) - have long been recognised. Chewing is of especial importance because of its dual role : it not only comminutes feed and feed residues directly, but il also assists microbial breakdown by providing access to plant tissues and by releasing soluble plant substrates (Baker and Harris, 1947 ; Reid *et al.,* 1962).

Quantitative data regarding the efficacies and the magnitudes of the contributions of the mechanisms of detrition are sparse. We present here initial results of a quantitative study of chewing in sheep which establish that this activity, during both feeding and rumination, makes a major, direct contribution to the physical breakdown of feed.

Methods

Particle size spectra (PSS)

Boluses and stomach contents were fractionated by wet-sieving, using a method similar to that of Evans *et al.* (1973), modified to reduce « matting » in the top sieve. Feed samples were soaked (30 min, without agitation) in artificial saliva before sieving.

Animals, Diet

Eighteen Romney Marsh wethers (48-56 kg BW) housed indoors in metabolism stands were used. Three had œsophageal and small rumen fistulae ; 3 had large rumen fistulae fitted with 81 mm i.d. cannulae.

The feed was 1050 g $DM.d^{-1}$ chaffed lucerne hay (*Medicago sativa,* L.) DM digestibility approximately 65%. Water and salt were freely available.

Table 1. - Apparent changes in the pool sizes (g) of total DM and of some particulate fractions in the contents of the ReRu of sheep during and following a meal of chaffed lucerne hay*

	Total DM	Particulate Fraction (sieve mesh)[a]				
		4 mm[2]	2	1	0.5	0.25
(a) Found in ReRu before feeding (0800 h)	267	6	7	21	58	64
(b) Ingested feed	710[b]	635	40	17	12	5
(c) Gross : (a) + (b)	977	641	47	38	70	69
(d) Found in ReRu at end of feeding (1300 h)	674	210	60	59	75	99
Net Changes						
(e) During meal : (c) - (d)	−303	−431	+13	+21	+ 5	+20
(f) During 19 h after meal : (d) - (a)	−407	−204	−53	−38	−17	−25

* Mean data from 3 sheep with large rumen fistulae, sampled 2 × before and 2 × after feeding, the 4 samplings being spread over 12 d ; on each occasion all contents of ReRu were removed, weighed and then mixed for sampling ;

[a] Amount of DM that would be retained on the successive sieves (Total DM × PSS of aliquot of digesta) ;

[b] Mean intake of the 3 sheep over 14 d, starting 2 d before first sampling ; 1050 g DM offered at 0900 h, refusals removed at 1300 h.

Collecting boli

Boli swallowed during feeding were collected from open œsophageal fistulae, mixed, sampled and the remainder returned continuously to the rumen. During collection of rumination boli, the fistula was covered by hand and only one bolus in 10 removed.

Rumination

Jaw activity was deduced from pressure changes in a balloon held against the lower jaw by a head halter. Continuous recordings for 5 d were used to establish 24 h rumination cycles.

Results and Discussion

The magnitude of the physical changes during the 24 h cycle of feeding and digestion.

The changes in the amounts of total DM and of several particulate fractions in the ReRu contents during feeding and during the post-feeding period in sheep fed 1 × day, are shown in table 1.

Feeding results in a net gain of DM and of all particulate fractions (table 1, compare lines d, a). However, when account is taken of gross gain (c), it is apparent that between the start and the end of feeding there have been substantial losses of DM and, especially, of the largest particulate fraction (e). By contrast, the other particulate fractions have increased, presumably because of breakdown of the largest fraction.

In the 19 h after the end of feeding substantial losses in total DM and in the largest particulate fraction continue, but now all particulate pools are decreased. (f).

The magnitude of these changes is indicated by the fact that between the start of one feed and the start of the next 24 h later, 726 g of particulate matter that would be retained on a 1 mm mesh sieve (i.e. the sum of material on 4, 2, 1 mm sieves), are reduced to 38 g. This cycle of accumulation and breakdown is repeated each day.

The importance of chewing in the comminution of feed.

The quantitative importance of chewing as a mechanism for comminution will be a function of its efficacy and the extent of exposure of feed and digesta to it.

The efficacy of chewing in the breakdown of feed, as determined by study of the PSS of boli, is high. Some 97% (w/w DM) of the feed

offered to these animals was too coarse to pass through a 1 mm sieve : after chewing during eating, only 48% of the swallowed food was still too coarse to pass (mean data, 3 sheep). During rumination shortly after the end of feeding, regurgitated boli contained 27% of DM that was too coarse to pass a 1 mm sieve, but after rechewing, the proportion in the swallowed boli was only 9% (mean data, 2 sheep). As time elapsed after feeding, the ratio (amount of coarse fraction in swallowed rechewed boli : amount of coarse fraction in regurgitated boli) remained almost unchanged, althought the proportion of coarse material in the regurgiatated boli declined, presumably reflecting progressive change in the PSS of the ReRu contents.

Thus, in these animals, a single chewing of feed or digesta reduced the proportion of coarse solids - the fraction retained on a 1 mm sieve - by a half or more.

All ingested feed is exposed to chewing, but at high rates of intake chewing may tend to be cursory and exposure limited. During rumination, however, chewing is deliberate and systematic. Further, exposure is generally high and, in terms of time spent ruminating, kg DM^{-1}, it is inversely related to the digestibility of the diet. Probably a more meaningful criterion is the proportion of the DM pool in the ReRu contents ruminated. In these animals, the proportion increased from some 12% during the first 4 h after one feed, to more than 90% in the 4 h before the next feed (table 2), while the 24 h turnover rate was approximately 2.

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Table 2. - Apparent proportion of ReRu DM pool ruminated in each successive 4 h period

Period*	Amount Ruminated[a]	Proportion of DM Pool[b]
0- 4 h	24 g	4%
4- 8	135	12
8-12	148	16
12-16	314	40
16-20	352	50
20-24	516	96

* Feed given at 0 h ; refusals removed at end of first 4 h.

[a] Min spent ruminating in each 4 h period (mean data from 12 intact sheep, 5 d each) × DM content of ruminated boli (mean data from 2 sheep with œsophageal fistulae), assuming 1 regurgitation. min^{-1}. All sheep offered 1050 g DM × d^{-1}.

[b] DM pool estimated from data obtained by slaughtering the 12 sheep (4 each at 0, 4 and 13 h).

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