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Effects of the amount and type of food eaten on secretion from fundic abomasal pouches of sheep

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1. The effects on gastric secretion of altering the amount and type of food eaten were examined in sheep with fundic abomasal pouches and in sheep which also had the antral region of the abomasum isolated into a pouch or removed (antrectomy). Secretion, which was continuous in all preparations, was collected over 24 h periods, and daily determinations of its acid and pepsin concentrations were made for periods of up to 10 weeks.

2. Experimental diets consisting of chaffed lucerne, meadow and wheaten hays were fed on *ad lib.* or restricted regimens.

3. Raising and lowering the dry matter (DM) intakes of lucerne chaff increased and decreased respectively the volume, acidity and acid and pepsin outputs (volume × concentration of acid or pepsin) of fundic pouch secretion.

4. Increases of 27–64% in the amount of lucerne chaff eaten, after changing from restricted to *ad lib.* feeding, were followed by increases in the volume (19–66%), acid concentration (4–10 mequiv. H^+/l, 3–9%) and acid output (18–76%) of pouch secretion.

5. With DM intakes of mixed lucerne and wheaten chaffs between 88 and 107% of those of lucerne, the secretion from the pouches was reduced to 45–88% of the volume and 39–77% of the acid output observed with the lucerne diet. Acid concentration was least affected, being unchanged in one series of observations and decreased by, at the most, 13 mequiv. H^+/l (12%) in another. Reverting to a diet of lucerne chaff reversed these effects: the volume was increased by 30–49%, acid concentration by 2–15 mequiv. H^+/l (2–14%), acid output by 38–68% and pepsin output by 30–43% although the intake of DM was the same or 6% less than that on the wheaten chaff mixture.

6. Secretion was greater when animals ate lucerne chaff than when they ate meadow chaff.

7. The changes in secretion according to diet were obtained in animals with antral pouches and antrectomy as well as in those with only fundic pouches.

8. It is argued in discussion that the markedly different abomasal secretions on different diets arise from abomasal stimulation due to the nature rather than the amount of digesta entering it and that although the pyloric antrum contributes to these changes it is not essential for their occurrence.

The influence of diet on gastric secretion in ruminants is poorly defined. Most of the evidence deals with the effect of the amount of food on gastric (abomasal) secretion (Masson & Phillipson, 1952; Hill, 1960; Ash, 1961*a*; McLeay & Titchen, 1970*a*). Although Kuimov (1952) and Hill (1960) have reported differences in abomasal secretion with foods of widely different dry matter (DM) content and physical form, there have been few studies on gastric secretion in animals eating comparable amounts of different quality foods of similar DM content and particle size. The following account deals with observations of this nature, and also with the effect of the amount of food eaten, on abomasal secretion. A preliminary report of some of the observations has been made (McLeay & Titchen, 1973).

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Table 1. *Composition of hays given as experimental diets to sheep (g/kg dry matter)*

	Hay		
	Meadow	Wheaten	Lucerne
Crude protein	172	74	195
Crude fibre	280	350	304
Diethyl ether extract	19	11	26
Ash	64	93	84
Nitrogen-free extract	465	472	391

EXPERIMENTAL

Animals and management

Eight ewes of Australian Romney or Corriedale breeds, or Merino–Border Leicester crosses, aged 1–2 years and weighing 24–45 kg, were used. They were kept in mobile crates in an animal house and habituated to feeding and management procedures for several weeks before use. Unless specifically stated otherwise, they had free access to food and always to water and block sodium chloride. The standard diet was chopped lucerne hay (lucerne chaff) fed *ad lib.* and renewed daily at 10.00–10.30 hours. The residues from the amount supplied the previous day were dried in an air circulating oven (Labmaster, Drug Houses of Australia Ltd, Sydney) at 100° for 24 h. The DM intake of each animal was calculated from the dry weight of the food given, and this in turn was determined by drying a 200 g (wet weight) sample of the fresh food.

Effect of quantity and type of food eaten on pouch secretion

Four sheep were used to study the effect of the quantity of food eaten on abomasal secretion. Daily collections of secretion were made at specific levels of intake, which were subsequently either lowered or raised. The sequence of the feeding regimen was, in two animals, *a–b–a*, and in the other two animals *b–a*, where *a* and *b* were different quantities of lucerne chaff offered.

Six sheep were used to study the effects of different foods on abomasal secretion. These animals were fed lucerne chaff and, after a series of collections of secretion had been made, their diet was changed to a mixture of equal parts of lucerne chaff and wheaten chaff, or to one of meadow chaff. The reverse change was studied in five animals. The sequences of the feeding regimens for the sheep are shown in Tables 2–5. The effects of the different diets on secretion were studied at differing levels of food intake. The particle sizes of the respective diets were similar and corresponded to those described by Weston (1966) for chopped lucerne and wheaten hays. The meadow chaff contained traces of lucerne hay which was added during chaffing to obtain similar particle sizes for the diets. In the present work we were concerned to make some observations on animals eating comparable amounts and hence wheaten chaff was not fed alone because of the variable intakes which occur with this material. Analyses are presented in Table 1.

Surgical procedures

In all animals, secretion was obtained from separated innervated pouches of the abomasum prepared from the fundic region as described by McLeay & Titchen (1970*a*). In addition, two animals had the whole antrum isolated into a pouch, and a 3rd animal was antrectomized. Continuity of the alimentary tract in these animals was restored by an abomaso-duodenal anastamosis. Exteriorization of the reticulum (Titchen, 1958) permitted its motility to be recorded (Carr, McLeay, Reid & Webster, 1971).

Collections of pouch secretion over a 24 h period were made with a 600 mm length of 20 mm diameter latex Penrose drainage tubing (Shieldtex, Baltimore, USA), secured around the pouch cannula by a rubber sleeve and led via a hole in the floor of the crate into a plastic pipe (length 450 mm and diameter 50 mm). The plastic pipe delivered secretion to the neck of a 4 l collecting vessel. The drainage tube was lightly weighted (3–4 g) and could move up and down inside the plastic pipe, allowing the animal to stand and lie without interfering with the collection of gastric juice. The volume of secretion obtained over the previous 24 h was recorded before fresh food was given each morning, and a sample taken for determination of acid and pepsin concentrations, which were made as described previously (McLeay & Titchen, 1970*a*). When peptic activity of a sample was determined, it was within 6 h of taking an aliquot from the total 24 h collection. Under similar dietary and collection conditions this gave comparable figures for peptic activity. The peptic activity in the fresh secretion could be expected to be greater because of losses which may occur with storage (Hunner, Hudson & Fletcher, 1969). When the gastric juice was stored for a further 24 h, either at room temperature or at 4°, a 20–30% loss in peptic activity resulted. Observations on secretory activity when sheep first ate freshly provided food were made with the aid of a fraction collector. Instead of the samples being taken into a 4 l vessel they were collected into one of a series of test-tubes changed at a selected interval. Each series of observations involved the serial collection of 15 min samples of pouch secretion, continuous recording of reticular motility and calculation of the amount of food eaten in the 4 h after fresh food was given. These procedures aided a closer examination of the initial responses on eating freshly provided food.

RESULTS

Quantity of food eaten and abomasal secretion

Table 2 provides a summary of the results for fundic pouch secretion in four sheep on *ad lib.* and restricted food intakes, for the DM eaten per 24 h, and for the volume, total acid concentration (acidity), and total acid output (volume × acidity) per 24 h. Values for the pepsin output of a pouch in one animal in which detailed observations were made are also presented.

Restriction of food intake from *ad lib.* levels was followed in two sheep (O and D1) by reductions in the volume, acidity, acid output, and, in the animal in which it was measured (Sheep O), pepsin output of the secretion. The effects were found to be

Table 2. *The effect of the quantity of lucerne chaff eaten on the secretion from fundic abomasal pouches of four sheep*

(Mean values with their standard errors; number of observations in parentheses)

Sheep	Type of preparation	Feeding regimen	Dry matter eaten (g/24 h) Mean	SE	No.	Secretion: Volume (ml/24 h) Mean	SE	No.	Acidity (mequiv. H^+/l) Mean	SE	No.	Acid output (mequiv. H^+/24 h) Mean	SE	No.	Pepsin output (mg tyrosine/24 h)* Mean	SE	No.
O	Fundic	*a*	715	29	(12)	1132	45	(12)	119	1·5	(12)	134	6·4	(12)	3181	199	(8)
		b	501	5†	(10)	829	19	(10)	112	1·0	(10)	93	2·6	(10)	2761	106	(9)
		a	824	35	(10)	1377	48	(13)	119	1·2	(13)	164	7·0	(13)	4743	135	(8)
F	Fundic	*b*	997	13†	(6)	1067	21	(6)	127	0·1	(3)	141	2·5	(3)	—		
		a	1265	39	(6)	1267	50	(9)	132	1·2	(8)	167	8·2	(8)	—		
G	Fundic and antrectomy	*b*	818	26†	(9)	716	49	(9)	121	1·7	(8)	88	7·1	(8)	—		
		a	1119	91	(3)	1064	35	(5)	125	1·3	(5)	133	5·4	(5)	—		
D1	Fundic and antral	*a*	1124	28	(8)	744	16	(8)	116	1·2	(8)	87	1·9	(8)	—		
		b	872	6†	(9)	656	20	(9)	111	1·3	(9)	73	2·8	(9)	—		
		a	1242	11	(15)	825	10	(15)	121	0·7	(15)	100	1·6	(15)	—		

a, *b*, different quantities of lucerne chaff offered; for details of feeding regimens, see p. 376. The changes were made in the order in which the observations are tabulated.

* Determined by method of McLeay & Titchen (1970*a*).

† Restricted intake. All others *ad lib.* feeding.

reversible when the animals were returned to an *ad lib.* regimen. Increases in the food intake on changing from restricted to *ad lib.* feeding in these sheep and in two others (F and G) were followed by increases in the volume, acidity, acid output and pepsin output (Sheep O) of the secretion. In all animals, increases in secretion associated with increases in their DM intake were detected in the 24 h collection made immediately following the changed intake. Maximum levels developed within 3 d and were subsequently maintained.

Abomasal secretion with different foods

Observations on lucerne chaff and a mixture of lucerne and wheaten chaffs. Five sheep with fundic pouches were used in this part of the study. One animal (Sheep L) also had an antral pouch and another (Sheep G) had undergone antrectomy by removal of an antral pouch. Initially the animals were given lucerne chaff *ad lib.* and later a mixture of equal parts of lucerne and wheaten chaffs. Observations on secretion commenced when the animals were eating amounts of DM comparable to those consumed before the change was made. Since voluntary food intakes were at first irregular when animals were changed from lucerne to any of the other diets fed *ad lib.*, the manner in which changes in the secretion occurred could not be studied.

The volume of secretion was most affected, and its acidity least, when mixtures of lucerne and wheaten chaffs were given instead of lucerne alone (Table 3).

The effect of a change from a restricted intake of lucerne to the mixed chaffs was studied in one of the animals with a fundic pouch (Sheep F, Table 2). The animal ate all 700 g (wet matter, WM) of food given of both rations and thus observations on secretion commenced as soon as the change was made. Reductions in secretion were evident within the first 24 h collection and were in volume, acidity and acid output (pepsin was not measured).

Four animals with fundic pouches, which included one with an antral pouch and one which had been antrectomized, were used to study the effect of changing the diet from a mixture of equal parts of lucerne and wheaten chaffs to lucerne chaff alone. These animals had been included in the study of the effects of the reverse change, i.e. from lucerne chaff to the mixture of lucerne and wheaten chaffs. Three of the animals were offered the mixture *ad lib.* and one animal (Sheep F) continued with food intake restricted to 700 g WM. Observations on pouch secretion began as soon as the change was made.

Increases occurred in the volume, acidity and acid and pepsin outputs (Table 4) within 48 h when the animals were returned to lucerne, with which the strongest secretory responses were obtained after 2–3 weeks.

Observations on lucerne and meadow chaff. The effect on secretion of a change of diet from chaffed lucerne to chaffed meadow hay was followed in two sheep, one with a fundic pouch (D 2) and one with a fundic pouch which had also had an antral pouch removed (G). Both animals were originally on a restricted food intake. Sheep D 2 received and ate 1000 g WM of both foods. The antrectomized animal (G) was given 1200 g WM of both and ate all the lucerne but not all the meadow chaff. Measurement of secretion was started 3 weeks after the change to meadow chaff. The amounts of

Table 3. *Food intakes and secretion from fundic pouches of five sheep whose diet was changed from lucerne chaff to a mixture of equal parts of lucerne and wheaten chaffs*

(Mean values with their standard errors: number of observations in parentheses)

Sheep	Type of preparation	Diet	Dry matter eaten (g/24 h) Mean	SE	Secretion: Volume (ml/24 h) Mean	SE	Acidity (mequiv. H^+/l) Mean	SE	Acid output (mequiv. H^+/24 h) Mean	SE	Pepsin output (mg tyrosine/24 h)* Mean	SE
I	Fundic	Lucerne	1236 (7)	28	2404 (10)	46	134 (7)	3	325 (7)	10·5	—	
		Lucerne–wheaten	1235 (29)	18	1445 (26)	31	126 (26)	0·5	182 (26)	4·1	2928 (17)	73
F	Fundic	Lucerne	1265 (6)	39	1267 (9)	50	132 (8)	1·2	167 (8)	8·2	—	
		Lucerne–wheaten	1194 (11)	35	754 (11)	28	119 (10)	1·6	88 (10)	3·8	1690 (5)	68
		Lucerne	600 (27)	0·4†	472 (21)	15	104 (20)	1·0	49 (20)	1·7	1242 (16)	41
		Lucerne–wheaten	599 (20)	0·5†	305 (20)	6	92 (20)	2·0	28 (20)	0·6	924 (12)	21
B	Fundic	Lucerne	1169 (6)	49	2217 (9)	39	120 (9)	2·0	226 (9)	8·3	—	
		Lucerne–wheaten	1250 (29)	12	1056 (26)	30	121 (26)	0·9	127 (26)	4·1	3372 (20)	119
L	Fundic and antral	Lucerne	1273 (6)	40	383 (9)	14	115 (9)	3·1	44 (9)	2·4	—	
		Lucerne–wheaten	1191 (33)	53	337 (31)	8	103 (30)	0·7	34 (30)	1·4	854 (22)	33
G	Fundic and antrectomy	Lucerne	1119 (3)	91	1064 (5)	35	125 (5)	1·3	133 (5)	5·4	—	
		Lucerne–wheaten	988 (28)	24	477 (32)	12	110 (30)	0·8	52 (30)	1·4	1259 (20)	53

* Determined by the method of McLeay & Titchen (1970*a*).

† Restricted intake. All others *ad lib.* feeding. In every instance the diet was initially chaffed lucerne hay and changed to a mixture of chaffed lucerne and wheaten hays.

Three weeks elapsed between each set of observations, except in animal F on the restricted intake regimen, in which observations commenced as soon as the change was made.

Table 4. *Food intakes and secretion from fundic pouches of four sheep when their diets were changed from a mixture of equal parts of lucerne and wheaten chaffs to lucerne chaff*

(Mean values with their standard errors; number of observations in parentheses)

Sheep	Type of preparation	Diet	Dry matter eaten (g/24 h)		Secretion: Volume (ml/24 h)		Acidity (mequiv. H^+/l)		Acid output (mequiv. H^+/24 h)		Pepsin output (mg tyrosine/24 h)*	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
B	Fundic	Lucerne–wheaten	1250 (29)	12	1056 (26)	30	121 (26)	0·9	127 (26)	4·1	3372 (20)	119
		Lucerne	1217 (26)	16	1579 (26)	37	136 (26)	0·5	213 (26)	5·7	4697 (16)	74
L	Fundic and antral	Lucerne–wheaten	1191 (33)	53	337 (31)	8	103 (30)	0·7	34 (30)	1·4	854 (22)	33
		Lucerne	1115 (29)	14	487 (30)	7	105 (30)	0·7	51 (30)	1·1	1218 (19)	19
G	Fundic and antrectomy	Lucerne–wheaten	988 (28)	24	477 (32)	12	110 (30)	0·8	52 (30)	1·4	1259 (20)	53
		Lucerne	986 (33)	20	622 (30)	15	116 (30)	0·8	72 (30)	2·2	1639 (19)	38
F	Fundic	Lucerne–wheaten	600 (17)	0·5†	328 (17)	6	101 (17)	1·2	33 (17)	0·7	1006 (11)	20
		Lucerne	600 (20)	0·4†	390 (18)	13	107 (18)	2·0	41 (18)	1·8	—	

* Determined by method of McLeay & Titchen (1970*a*).

† Restricted intake. All others, *ad lib.* feeding.

The observations were made first on the mixture of lucerne and wheaten chaff and later on chaffed lucerne hay alone. The observations on sheep F were made during food intakes restricted to 600 g dry matter/d.

Table 5. *Food intakes and secretion from fundic pouches of two sheep in which the diet was changed from chaffed lucerne hay (A) to chaffed meadow hay (B) and then back to chaffed lucerne hay*

(Mean values with their standard errors: number of observations in parentheses)

					Secretion					
Sheep	Type of preparation	Diet	Dry matter eaten (g/24 h)		Volume (ml/24 h)		Acidity (mequiv. H^+/l)		Acid output (mequiv. H^+/24 h)	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE
D2	Fundic	A	843 (6)	1·7*	563 (6)	25	131 (6)	4·6	72 (6)	0·8
		B	832 (15)	32*	363 (15)	15	112 (15)	1·8	41 (15)	1·9
		A	882 (15)	6·9*	483 (15)	9	128 (15)	0·9	62 (15)	1·5
G	Fundic and antrectomy	A	1008 (10)	6*	359 (10)	10	113 (10)	1·0	40 (10)	1·1
		B	735 (14)	29	236 (14)	23	88 (14)	2·9	23 (14)	1·8
		A	1058 (16)	8*	444 (16)	5	111 (16)	0·9	49 (16)	0·9

* Restricted intake. All others, *ad lib.* feeding. The changes were made in the order in which the observations are tabulated: A–B–A.

food eaten and secretion by the fundic pouches in these animals are presented in Table 5.

Change from meadow chaff to lucerne chaff. Secretion from the fundic pouches of Sheep D 2 and G increased when they were again given lucerne chaff (Table 5). Sheep G ate all of the 1200 g WM of lucerne given within 24 h, as it had before the change to meadow chaff. Increased secretion was evident within the first 24 h collection and was subsequently maintained.

Nature of food and the secretory response on eating

In one animal with a fundic pouch only (Sheep I) observations were made of the secretory responses when the animal first ate lucerne chaff or a mixture of equal parts of lucerne and wheaten chaffs. The animal ate comparable amounts of DM of these foods when they were given *ad lib.* The observations began when fresh food was first made available, and extended over the subsequent 4 h.

In five experiments with lucerne chaff and in three experiments with the lucerne–wheaten chaff mixture, the volume and acidity of the secretion and acid and pepsin outputs were shown to increase markedly when the animal first ate. Differences in the secretory response occurred depending on the type of food eaten (Fig. 1). The volume of secretion when lucerne chaff was eaten was more than twice that obtained with the mixture of lucerne and wheaten chaffs. With lucerne, secretion of pepsin reached a peak within 90 min of the start of feeding. In contrast, secretion of pepsin was more gradual and its output was less when a lucerne–wheaten chaff mixture was eaten (Fig. 1). In the five experiments on the secretory response to eating lucerne chaff, the concentration of pepsin in the 15 min samples of secretion was increased when greater amounts of lucerne were eaten and this led to increased pepsin output, although there were no rises in the volume of secretion. In contrast, when the animal ate greater amounts of the lucerne–wheaten chaff mixture, the pepsin concentration in the secretion did not increase, and increased pepsin output was then related to the increase in the volume of secretion.

Reticular motility differed according to which food was given. With comparable DM intakes there were more reticular contractions with the lucerne–wheaten chaff mixture over a 4 h period, although the frequency of reticular contractions in the first 15 min of eating freshly provided food was higher with lucerne (Fig. 1). The animal spent more time eating when given the lucerne–wheaten chaff mixture than when given the lucerne chaff, and in two of the three experiments with the mixed chaffs, ate more of the mixture than when given lucerne chaff.

Marked differences in secretion from the fundic pouch of Sheep I according to the type of food eaten were also found with the 24 h collections of secretion (Table 3).

DISCUSSION

Previous reports that lowering or raising food intake respectively lessens or increases continuous fundic pouch secretion in sheep (Masson & Phillipson, 1952; Hill, 1960; Ash, 1961 *a*; McLeay & Titchen, 1970 *a*) have been confirmed (Table 2; Table 3,

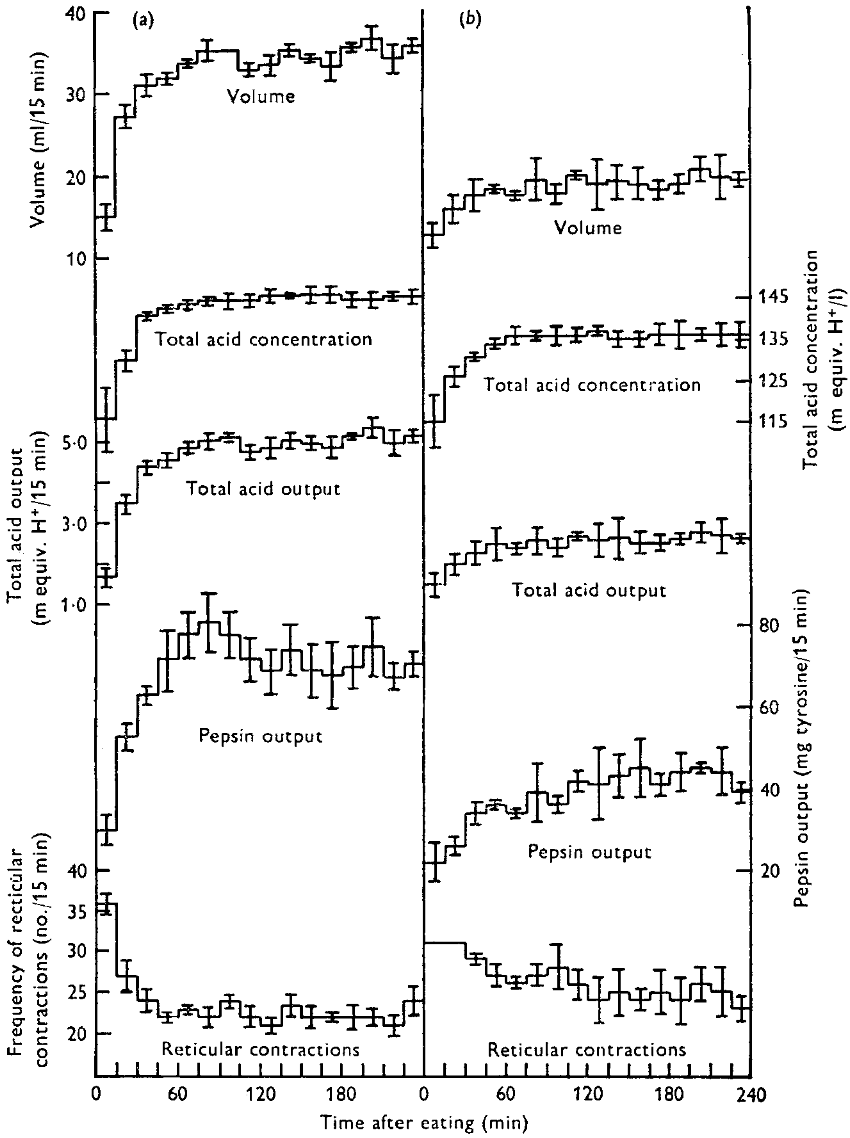

Fig. 1. Fundic pouch secretion and the frequency of reticular contractions in sheep I in the first 4 h after eating (*a*) lucerne chaff and (*b*) a mixture of equal parts (by weight) of lucerne chaff and wheaten chaff. The values are the mean of five observations for (*a*) and three observations for (*b*); the standard errors of the mean are represented by vertical bars.

animal F). The experiments with different foods have shown that secretion is greater in volume, acidity and pepsin on better-quality foods (Tables 3, 4 and 5). This extends reports previously made by Kuimov (1952) and Hill (1960). In the present work, changes in secretion according to the amount and type of food eaten were obtained in preparations in which the antrum was entirely removed (Tables 2, 3, 4 and 5, animal G) or separated into a pouch with which food did not come in contact (Table 2, animal D 1; Tables 3 and 4, animal L). The demonstration of such changes emphasizes the contribution made by factors other than direct antral stimulation in the regulation of gastric secretion in ruminants.

When food is first presented, changes associated with its ingestion are dominant influences in the stimulation of gastric secretion. These include psychic, gustatory, olfactory and tactile stimuli, and their influence can be expected to be strongest for up to 4 h or so after fresh food has been provided, since at this time housed animals usually eat most avidly (Fig. 1, and in the observations of Hill (1960), Kuimov (1952), and McLeay & Titchen (1970*a*)). Psychic stimulation of gastric secretion and motility in sheep, in association with the presentation of food, has been suggested previously from increased fundic pouch secretion (McLeay & Titchen, 1970*a*) and increased frequency of contractions of the reticulum and rumen which occur when ruminants anticipate being fed (Quin & Van der Wath, 1938; Dedashev, 1959; Hill, 1960; Reid, 1962; Sellers, Stevens, Dobson & McLeod, 1964). It may be concluded that the vagus nerve mediates these responses, and it is suggested that there will be stronger vagal excitation when more attractive food is provided. This conclusion is in keeping with the observations that when a sheep first ate lucerne chaff, reticular contractions were more frequent than when it first ate a mixture of lucerne and wheaten chaffs (Fig. 1). Supporting evidence, indicating that vagal stimulation of the abomasum had occurred, was the increase in concentration of pepsin. The concentration of pepsin increased when greater amounts of lucerne were eaten, but not when the animal ate greater amounts of the lucerne–wheaten chaff mixture.

The effect of the quantity of food on abomasal secretion has been ascribed to a change in the rate of passage of digesta through the abomasum (Masson & Phillipson, 1952; Hill, 1960; Ash, 1961*a*; Hill, 1965, 1968). In the present experiments, although similar quantities of different diets were eaten, it could not be argued that there were similar flows of digesta into the abomasum. Phillipson & Ash (1965) suggested that there would be less flow of digesta from the omasum into the abomasum with more readily fermented diets. Hogan (1964) estimated that in sheep receiving 700 g of lucerne–wheaten chaff mixture or 800 g of lucerne chaff, flow from the rumen was less on lucerne. In a further study, it was estimated that daily digesta flow from the rumen was similar with *ad lib.* intakes of lucerne or wheaten diets, despite a substantially higher intake of organic matter on the lucerne diet (Weston & Hogan, 1967). These findings do not support the idea that the marked changes in secretion observed with the different diets resulted from changes in the amount of digesta entering the abomasum. Instead they support the view that if markedly different secretion with different diets arises from abomasal stimulation, it is the nature rather than the quantity of digesta entering the abomasum which is most important.

The introduction of volatile fatty acids (VFA) into the abomasum stimulates secretion, which varies with their concentration (Ash, 1961*b*). The concentrations of acetate, propionate, butyrate and valerate in digesta leaving the rumen of sheep fed on lucerne hay were found by Hogan & Weston (1967) to be twice those in sheep fed on wheaten hay. Although absorption of VFA occurs in the omasum (Barcroft, McAnally & Phillipson, 1944; Bueno, Goodall, Kay & Ruckebusch, 1972) digesta containing substantial concentrations of VFA have been reported to enter the abomasum (Ash, 1961 *b*), where metabolism and further absorption of them may occur (Pennington, 1952; Ash, 1961 *b*; Engelhardt, Erhlein & Hörnicke, 1968). We have shown that irrigation of an antral pouch with salts of VFA stimulates fundic secretion (McLeay & Titchen, 1971), and that propionate and butyrate are more effective than acetate (L. M. McLeay & D. A. Titchen, unpublished observations). These observations support the contention (Hill, 1960) that the differences in abomasal secretion observed when sheep ate hay or concentrates may have been due to the amounts and proportions of VFA produced on the two diets, and are particularly relevant to our experiments.

The presence of peptides and amino acids in the abomasal digesta could be another stimulus to secretion. These agents stimulate gastric secretion in the dog by release of the hormone gastrin (Elwin & Uvnäs, 1966).

In the simple stomach, gastrin is normally present in high concentrations in the pyloric antrum. Nervous, physical and chemical stimulation of the antrum lead to gastrin release (Grossman, 1967). In sheep, gastrin release from the antrum has not been reported but gastric secretion can be increased by stimulation of the pyloric antrum (Hill, 1960; McLeay & Titchen, 1971) and by administration of the synthetic analogue of gastrin, pentagastrin (McLeay & Titchen, 1970 *b*). In some of the preparations used here the antrum was isolated as a pouch and hence was not subjected to physical and chemical stimulation by abomasal contents, although its vagal supply was presumably intact. Secretory responses observed in these animals and in one which had an antrectomy were similar in type to those of animals with intact antra. There is thus evidence of other than antral factors contributing to the secretory responses to different diets. These factors may include gastrin itself. Release of gastrin from the duodenum has been demonstrated in man (Stern & Walsh, 1972) and gastrin has been extracted from the fundic as well as the antral regions of abomasa of sheep (Anderson, Fletcher, Pitts & Harkins, 1962). The reflex stimulation of abomasal secretion by excitation of receptors in the reticulo-rumen resulting from distension and VFA has been proposed (Hill, 1960, 1965, 1968). Such reflex stimulation of salivary secretion from the reticulo-rumen has been demonstrated and its digestive importance adduced (Kay, 1966). A number of reflex responses of the reticulo-rumen to abomasal stimulation which occur by way of abomasal afferents have been demonstrated (considered in reviews by Titchen, 1968; Carr, McLeay & Titchen, 1970), but little attention has been paid to reflexes with afferents arising from the fore-stomach which mediate effects on the abomasum.

It is apparent that the influence of diet on abomasal secretion is not simple. Some of the possible mechanisms involved have been discussed but clearly these and other aspects of the control of gastric secretion require further study for a full appreciation of how the secretory activity of the abomasum is affected by diet.

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