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THE COMPOSITION OF THE DIGESTA LEAVING THE ABOMASUM OF SHEEP

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The digesta entering the abomasum of sheep consist of the residual products of the fermentations that proceed in the rumen and reticulum, which pass through the omasum to the abomasum where they are diluted and subjected to peptic digestion by the gastric juice secreted by the gastric glands of that viscus. Measurements of the volumes of digesta leaving the abomasum under various experimental conditions (Phillipson, 1951) indicated that as much as 10–12 l. pass to the duodenum in 24 hr. Analyses of certain constituents of the digesta leaving the abomasum suggest that the volume of gastric juice is considerable and there is evidence to suppose that water is lost from the digesta before they enter the abomasum. That absorption of water from the omasum is the probable explanation is substantiated by the recent work of Garton (1951) who found that both magnesium and phosphorus are concentrated in the omasal contents, an observation in keeping with the well-known fact that omasal contents contain less water than those of any other part of the stomach. The experiments described in this paper support this view. There is little information available on the rate of secretion and composition of the gastric juice of the sheep and for this reason a study of the juice obtained from abomasal pouches was undertaken. The data so obtained allow calculations to be made showing that the dilution of omasal contents by gastric juice is so large that gastric juice is the greater in volume of the two components, which together form the abomasal contents.

METHODS

Surgical. The sheep used for the experiments previously described (Phillipson, 1951) also provided samples of rumen contents and of the material passing into the first part of the duodenum. Rumen liquor was withdrawn by suction and duodenal contents were obtained by opening a Perspex cannula situated immediately caudal to the pylorus and waiting for a gush of digesta to flow from the cannula.

Samples were obtained in this way at hourly intervals while the sheep were feeding normally. Samples of well-mixed whole stomach contents of slaughtered sheep were used to compare the rumen, omasal and abomasal contents.*

* The authors are indebted to Drs J. Tosic and R. L. M. Synge for these samples.

Abomasal pouches were prepared either according to the original technique of Pavlov (1910) or according to the modification of this technique developed by Hollander & Jemerin (1938). Hollander pouches are preferable to Pavlov pouches as the nerve supply to the pouch receives less damage during the operation than with the Pavlov technique.

There are two principal difficulties to overcome in performing these operations. The first is to prevent regurgitation of rumen contents (which often occurs) when major surgical interference is applied to the abomasum. This was avoided by using animals previously fitted with rumen cannulae through which the rumen and reticulum contents could be removed before the operation started. The rumen liquor was strained off and placed in an incubator until the operation was over and was then replaced in the rumen. The second difficulty is due to the large flaps of mucosa that line the abomasum which make the formation of a pouch difficult. We have tried various ways of overcoming this trouble but our successes have been due to the exercise of extreme care in suturing together the cut edges of the flaps.

We have performed this operation on 6 sheep but have created only 2 successful pouches, one after 'Pavlov' and one after 'Hollander.' Operative failures were due at first to regurgitation of stomach contents, and when this was overcome, to perforation of the partition between the pouch and the body of the abomasum.

The secretion from the Pavlov pouch after 2 months became so small that further work with the animal was abandoned. The pouch on post-mortem examination was in a healthy condition and there was no apparent reason why it was not secreting. The second sheep with the Hollander pouch is still alive and healthy although the operation was performed over 2 years ago. The pouch continues to secrete apparently normal gastric juice although for one period, a year after the operation was performed, the quantity of secretion was very low and the juice was neutral or had a low acidity. This change was associated with a change in the feeding regime, for it later returned to normal. This sheep was subsequently fitted with a cannula placed in the pyloric part of the abomasum so that the gastric juice and abomasal contents could be compared.

Chemical. Samples were dried at 105° C. to constant weight to determine dry matter. The same samples were subsequently ashed at 500° C. to obtain total ash.

Total volatile fatty acids were determined in the usual way by steam distillation and titration of the distillate with carbonate-free 0·02 N-NaOH under CO_2-free conditions, using phenol red as an indicator. Chloride did not appear in the distillates in sufficient quantity to be detected by the addition of $AgNO_3$. Chloride was estimated in stomach contents by the method of Van Slyke & Sendroy (1923). A modification of this method was used to determine chloride in weighed samples of the stomach contents. The 'Volhard' titration was used to determine chloride in filtered gastric juice; this is a simpler procedure than the Van Slyke & Sendroy method, and, in the absence of mucus, gives true chloride values. No significant difference was found between this method and that of Van Slyke & Sendroy when both were applied to the same sample of filtered gastric juice. pH was determined by the glass electrode.

RESULTS

Volatile fatty acids in the rumen and duodenal contents

Samples taken from the rumen and duodenum of three sheep, nos. 2, 494 and 495, and duodenal samples from two more animals, nos. 4 and 12, were studied. They were taken at hourly intervals over a 12 hr. period, the rumen and duodenal samples being obtained within a few minutes of one another. The results confirm previous observations (Phillipson & McAnally, 1942; Elsden, Hitchcock, Marshall & Phillipson, 1946) that the concentration of volatile fatty acid in the material entering the duodenum is seven or more times less than that of the rumen. The results are given in Table 1.

TABLE 1. The concentration of volatile fatty acid in the rumen and duodenal contents (m.equiv./l.)

Sheep no.	Diet	No. of samples	Rumen Range	Rumen Mean	Duodenum Range	Duodenum Mean
2	*B*	12	53–87	69	2–6	3·5
2	*B*	13	55–98	73	2–6	3·5
12	*B*	13	—	—	3–6	4·6
494	*A*	13	83–123	102	10–19	14
495	*A*	13	82–125	103	5–11	9
4	*A*	13	—	—	10–14	12

Diet *A* = Hay plus linseed meal 2 parts
„ crushed oats 1 part

Diet *B* = Hay plus ground maize 4 parts
„ crushed oats 1 part
„ wheat bran 1 „
„ linseed meal ½ „
„ fish meal ½ „

The quantity of food passing to the duodenum is between 400 and 500 ml./hr.; thus the quantity of volatile fatty acid leaving the stomach is considerably less than 1 g./hr. when expressed as acetic acid.

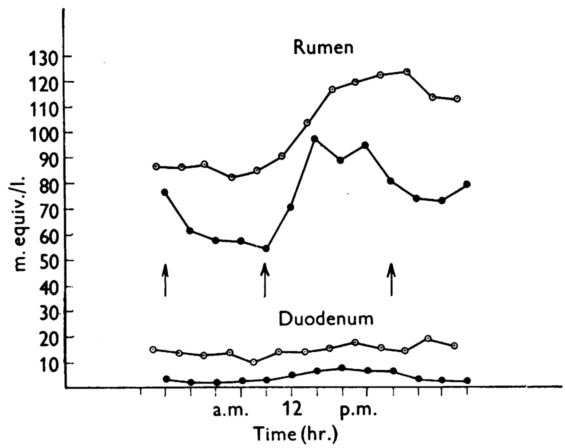

Fig. 1. The daily variation in total volatile acid concentration in the rumen and in the digesta leaving the abomasum. Hay was fed at 7 a.m. and 4 p.m., while the mixtures of meals given at 11 a.m. were different. ⊙——⊙, diet *A* (sheep no. 494); ●——●, diet *B* (sheep no. 2).

In diet B, the volatile acid concentration of samples taken from the duodenum changed in the same direction as those found in samples taken from the rumen although the variation was small (Fig. 1).

The titratable acidity of the food entering the duodenum was high. In only two samples was there obvious contamination with bile. It was noted that the common bile duct entered the duodenum approximately 30 cm. from the pylorus so that the samples were collected before they have been contaminated to any appreciable extent with bile or pancreatic juice.

The range of values found from 7 a.m. to 7 p.m. are shown in Table 2.

TABLE 2. The pH and total acidity of the duodenal contents

Sheep no.	Diet	No. of samples	pH Range	pH Mean	Total acidity m.equiv./l. Range	Total acidity m.equiv./l. Mean
2	*B*	12	2·4–4·7	3·1	—	—
2	*B*	13	2·6–3·5	2·9	48–67	59
12	*B*	13	2·5–3·2	2·9	52–74	65
494	*A*	13	3·0–4·2	3·4	39–50	44
495	*A*	13	2·3–3·2	2·8	43–62	53
4	*A*	13	2·4–3·4	2·8	46–55	51

Two relationships were found to exist which are indicative of the variation in the volumes of the two components of the mixture leaving the abomasum, namely omasal contents and gastric juice. Total ash and chloride, when calculated as g./100 g. of the dry matter, varied inversely with the dry matter,

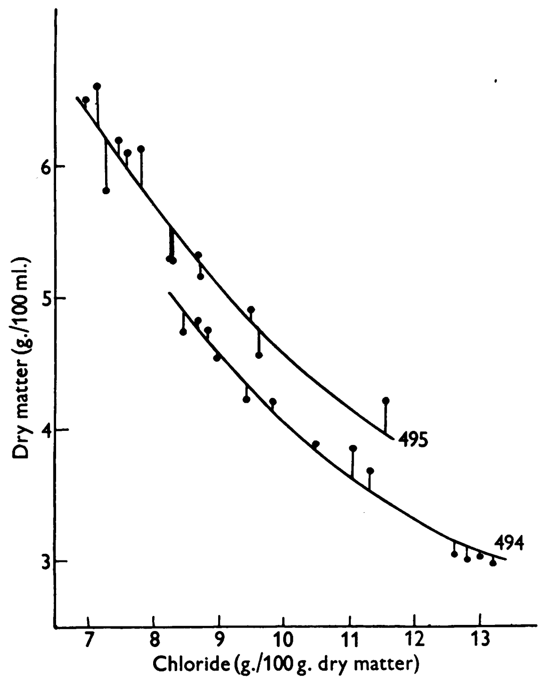

Fig. 2. This diagram shows the fit of an equation estimating dry matter from its chloride content, for two sheep. Although the means of the two animals were different, the coefficients expressing the relationship were similar and it was possible to make a combined estimate. As the diagram shows, the relationshi was curvilinear.

as shown in Fig. 2. Chloride accounted for 48–58% of the total ash with two exceptions out of 26 so that the ratio dry matter/total ash has greater variation than the ratio chloride/dry matter. These relationships are to be expected as the material leaving the omasum has a dry-matter content of approximately 20 % while the chloride concentration, as will be shown later, is small compared with that of the gastric juice. An inverse relationship, therefore, can be expected.

The concentration of chloride when expressed as a percentage of the liquor does not bear a close relation to the dry matter. On occasion both chloride and dry matter were diluted. This can only mean that a material low in chloride with a high water content enters the abomasum. This could be drinking water or rumen liquor. If, however, as sometimes occurred, this dilution was accompanied by an increase in volatile acids it is more probably due to rumen liquor passing through to the abomasum without the concentration which would be expected to occur in the omasum, for otherwise the concentration of dry matter would be high.

A close examination of the results of serial samples taken over 12 hr. from sheep nos. 494 and 495 is interesting because these sheep were fed on the same ration and the samples were taken on the same day under identical conditions. Both the sheep were in metabolism cages so that the food and water intake were controlled. On the day of the experiment the volume of water drunk by each was practically the same and was a little greater than 2 l.

TABLE 3. The variation in rumen and duodenal contents of sheep nos. 494 and 495 over 12 hr.

	Sheep no. 494		Sheep no. 495	
	Range	Mean	Range	Mean
Duodenum				
pH	3·0–4·2	3·4	2·3–3·2	2·8
Total acidity m.equiv./l.	39–50	44	43–62	52
Volatile acid m.equiv./l.	10–19	14	5–11	9
Chloride m.equiv./l.	109–120	114	119–135	128
Chloride g./100 g. dry matter	8·5–13·2	10·7	6·9–11·5	8·4
Dry matter g./l.	30–48	39	42–66	55
Ash g./100 g. dry matter	14–25	20	13–20	16
Rumen				
Volatile acids m.equiv./l.	83–123	102	82–125	103
Chloride m.equiv./l.	7–11	8	7–13	9

The complete analysis for these two animals is given in Table 3. Chloride is expressed both as g./100 g. dry matter and as m.equiv./l. The hourly variations are given in Fig. 3.

Comparing sheep nos. 494 and 495, there is little difference between the concentrations of volatile acid and chloride in the rumens of these animals. The chloride concentrations in the rumen were consistently low but higher values have been found in other sheep. The composition of the food entering the omasum is similar as regards these two constituents. Subsequent variation in the material leaving the abomasum must have been brought about during the passage of food through the omasum and abomasum. The striking difference is that the acidity, the chloride concentration as m.equiv./l. and the dry matter are greater in the samples taken from sheep no. 495 than in those taken from sheep no. 494, while conversely, volatile acids, ash and chloride as a percentage of the dry matter are less concentrated in sheep no. 495 than in sheep no. 494. The interpretation of this difference will be discussed later.

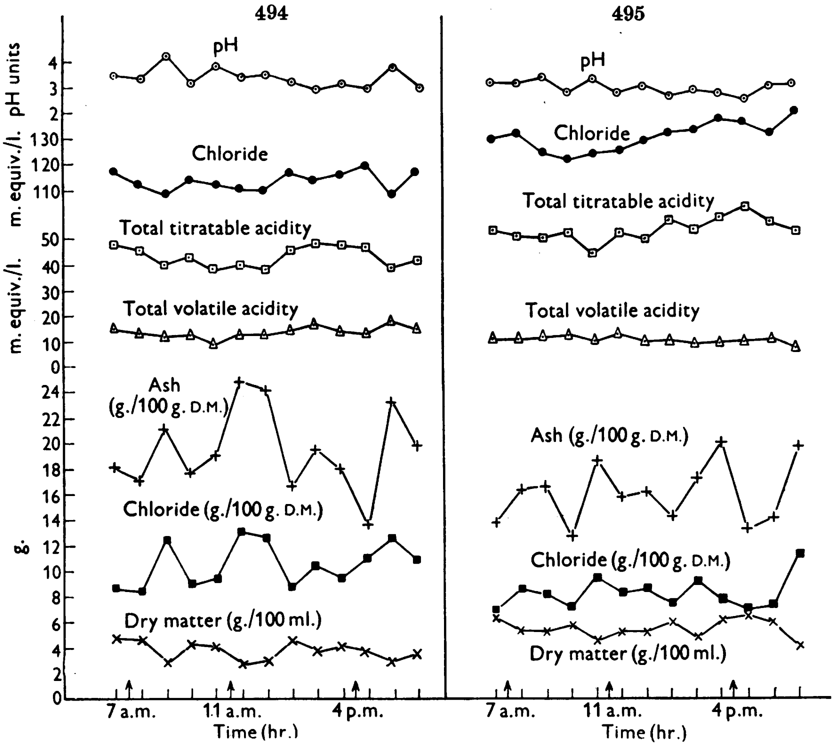

Fig. 3. The variations found in the digesta leaving the abomasum of sheep 494 and 495. Both animals received identical treatments and food. The arrows indicate the times at which food was given. Hay was fed at 7 a.m. and 4 p.m. while a mixture of meals was given at 11 a.m.

The secretion of gastric juice from abomasal pouches

The Hollander pouch. Large samples of juice were obtained by continuous collection throughout the day and night from the sheep with the Hollander pouch while kept in a metabolism cage. The acidity and concentration of chloride contained in the juice were estimated and are given in Table 4.

Chloride varied from 153 to 165 m.equiv./l. Titratable acidity varied over a greater range, 66–117 m.equiv./l., and there is no apparent correlation between acidity and chloride concentration. The range for titratable acidity was 66–105 m.equiv./l. during the day but 86–117 m.equiv./l. during the night. There was no difference, however, between the day and night concentrations of chloride.

TABLE 4. Composition of gastric juice obtained from a Hollander pouch of the abomasum

Duration of collection	pH	Acidity (m.equiv./l.)	Chloride (m.equiv./l.)
9 a.m.–6 p.m.	1·22	95	153
6 a.m.–9 a.m.	1·20	105	160
10 a.m.–6 p.m.	1·24	69	153
10.30 a.m.–5 p.m.	1·32	66	153
10 a.m.–6 p.m.	1·10	98	160
6 p.m.–7 a.m.	1·28	106	160
6 p.m.–7 a.m.	1·30	107	153
6 p.m.–6 a.m.	1·20	97	153
6 p.m.–10.30 a.m.	1·16	86	160
5 p.m.–9 a.m.	1·17	86	160
6 p.m.–10 a.m.	1·13	104	160
10 p.m.–10 a.m.	1·05	117	165

During the day and night 121 samples for analysis were collected. These showed that the acidity of the juice under normal circumstances ranged from 9 to 128 m.equiv./l., the mean being 86. Total chloride ranged from 147 to 177 m.equiv./l. with a mean of 158. Fasting juice had a wider and lower

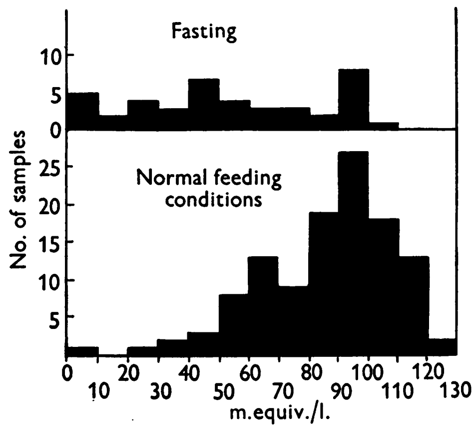

Fig. 4. A histogram showing the distribution of the samples of gastric juice of different titratable acidity during normal feeding and during fasting, collected from the sheep with a Hollander pouch.

range of acidity; 2–107 m.equiv./l., the mean being 51; total chloride remained at nearly the same level as before, 143–165 m.equiv./l., with a mean of 153, only 5 m.equiv./l. lower than normal juice. A histogram of the results is given in Fig. 4.

The Pavlov pouch. The acidity of the juice collected from the sheep with a Pavlov pouch was less. Large collections were not made but series of 7–10 samples were collected throughout the daylight hours and the results are given in Table 5. Samples collected at the end of the day often had a low titratable acidity and a pH over 6. This sheep developed an infection after the first few collections and cloudy alkaline juice was obtained from the pouch. After a course of penicillin the sheep recovered and the juice became clear and acid again. The figures are given not because those for acidity can be taken as representative of normal juice but to show that the chloride concentration remained relatively constant in spite of the wide fluctuations in acidity, and varied from 141 to 161 m.equiv./l. which is only slightly less than that of the gastric juice obtained from the Hollander pouch. A single sample of gastric juice from a third sheep, collected before the partitions between the pouch and the body of the stomach perforated had a chloride concentration of 153 m.equiv./l.

TABLE 5. Composition of gastric juice collected from a Pavlov pouch of the abomasum

No. of samples	Acidity (m.equiv./l.)		Chloride (m.equiv./l.)	
	Range	Average	Range	Average
7	21–52	31	152–158	156
14	3–38	18	150–154	153
8	5–37	13	147–152	150
11	2–31	9	147–153	151
9	59–88	77	147–160	154
8	46–59	52	153–161	158
7	17–62	26	141–151	148

The quantity of juice secreted. The total juice secreted from the Hollander pouch was collected on 14 occasions over a 24 hr. period. The quantity during the first series of collections made from 2–3 months after the operation varied from 855 to 1185 ml./24 hr. over a series of 10 collections. A further series of 4 collections were made 5–6 months after the operation and the volume varied from 826 to 1053 ml./24 hr. The average figure for all collections was 955 ml. Fasting reduced the flow, a volume of 695 ml. being collected during the second 24 hr. without food.

Three 24 hr. collections have recently been made from this sheep now more than 2 years after the operation. The volume collected ranged from 540 to 660 ml.

This sheep was maintained under normal conditions on a normal diet; a salt lick was provided but otherwise no precautions were taken to rectify the loss of chloride and acid from the body. Her water consumption, measured on 14 consecutive occasions, varied from 700 to 2980 ml./24 hr. which is a range usually found for sheep maintained under similar conditions.

The influence of feeding on gastric secretion. The sheep with the Hollander pouch was fed with hay at 7 a.m. and 4 p.m. while a mixture of concentrated foodstuffs was given at 11 a.m. The volume of juice passed hourly from 9 a.m. to 6 p.m. was determined on eight occasions while further collections over shorter periods were made on seven occasions. The results which are given in Table 6 show no regular response to feeding.

TABLE 6. Variation in rate of secretion of gastric juice throughout the day

Time	No. of measurements	Range (ml.)	Average (ml.)
9 a.m.–10 a.m.	9	19–75	39
10 a.m.–11 a.m.	12	22–68	46
11 a.m.–12 noon	15	25–86	38
12 noon–1 p.m.	12	26–75	45
1 p.m.–2 p.m.	12	21–60	41
2 p.m.–3 p.m.	11	27–75	46
3 p.m.–4 p.m.	9	23–55	39
4 p.m.–5 p.m.	11	23–59	45
5 p.m.–6 p.m.	8	19–60	36

In some of the experiments there was a rhythm in the volume of juice secreted, and two waves appeared, a small wave occurring in the morning, followed later by a larger increase, reaching its peak in the middle of the afternoon. The time intervals of these waves were irregular, showing no clear trend.

The rate of secretion during fasting, however, was more regular and the two waves were regular and distinct and in four experiments a high rate of secretion was found. The lowest rate was noted between 12.30 and 1.30 p.m. and was followed by a wave of increasing secretion reaching its peak between 2.30 and 3.30 p.m. We have not observed any responses that suggest 'psychic' stimulation, nor was there any immediate response to feeding, facts which suggest that secretion as a result of vagal stimulation is not important.

The chloride concentration in stomach contents. The small variation in the concentration of chloride in the gastric juice in both animals suggested that these values could be used to calculate the dilution of omasal contents by gastric juice. Contents from different parts of the stomach of sheep killed at definite times after a feed of hay were used. Liquor was expressed from the contents and the chloride concentration was determined in measured aliquots. Weighed samples were also taken and the total chloride content determined. The results obtained from 7 sheep are given in Table 7.

TABLE 7. Concentration of chloride in different parts of the compound stomach of the sheep (*a*) m.equiv./l. of stomach liquor. (*b*) m.equiv./kg. of whole stomach contents

	1		2		3		4		5		6		7	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
Rumen	15	—	12	24	10	18	15	17	10	10	15	23	10	7
Reticulum	—	—	—	—	29	25	—	—	—	—	—	—	12	12
Omasum	40	—	38	54	42	52	53	39	—	41	58	51	41	41
Abomasum	114	—	119	119	118	118	123	113	129	127	124	119	128	128

The contents of the rumen and reticulum were separated in two animals and in both the concentration in the reticulum exceeded that of the rumen. In the remaining sheep the contents of the rumen and reticulum were mixed together. The method of determining chloride on the weighed samples was not satisfactory. It was difficult to obtain representative samples and the volumes of material used were troublesome to handle; there was considerable variation between different samples from the rumen. With omasal and abomasal contents duplicates agreed to within 10% but with the small concentration found in the rumen contents agreement varied from 35 to 50%. The virtue of the weighed samples, however, was that they showed that the concentrations of chloride in the muslin filtrates were of the same order as those of whole stomach contents.

The required dilution of omasal contents by gastric juice to give the abomasal concentration found are given in Table 8. It has been assumed that the chloride content of gastric juice is 157 m.equiv./l. which is the average figure for all estimations from both types of pouch.

TABLE 8. The quantity of omasal contents which, when added to 100 ml. gastric juice containing 157 m.equiv./l. of chloride, will produce the concentration of chloride present in the abomasum

(*a*) Based on omasal liquor. (*b*) based on whole omasal contents.

Sheep no.	(*a*)	(*b*)
1	67	—
2	47	58
3	51	56
4	49	59
5	—	50
6	35	56
7	33	32
Average	47	52

The fact that the concentration of chloride in the omasum is higher than that in the rumen but lower than that in the abomasum may be due to three causes. Chloride may be concentrated as a result of absorption of water in the omasum, but this is unlikely to be the sole cause since the increase is large. It may be due to passage of chloride from the blood, for as the epithelium of the rumen is permeable to chloride (Masson & Phillipson, 1951) it is probable that that of the omasum is equally permeable; or it may be due to backward diffusion from the abomasum. If backward diffusion occurs to any extent then the pH of the omasal contents would probably be lower than that of the rumen but this is not so (Garton, 1951). In order to see whether the omasal juice possessed peptic activity the omasal contents were acidified with dilute HCl so that the pH was reduced to 1, and were then incubated with dried sheep's fibrin, but it was found that the omasal liquor had little or no power of digesting dried sheep's fibrin, in contrast to abomasal liquor which rapidly disintegrated this material.

A comparison of gastric juice and abomasal contents of the same sheep. After a Perspex cannula had been inserted into the pyloric part of the abomasum of the sheep with the Hollander pouch it was possible to compare the chloride concentration of the juice and the abomasal contents in the same sheep from hour to hour.

A series of four sets of samples extending from 7 a.m. to 7 p.m. were taken and the chloride concentration in the abomasal contents and in the gastric juice was determined at hourly intervals. In order to calculate the quantity of omasal contents needed to produce the dilution of gastric juice found to be present at each hour in the abomasum the average figure for the concentration in the whole omasal contents given in Table 8, column *b*, was taken. This was 46 m.equiv./kg. The specific gravity of gastric juice is so close to one that volumetric measurements can be converted to gravimetric measurements without making any appreciable difference to the results. The quantities of omasal contents calculated on this basis which would need to be added to 100 g. of gastric juice are given in Table 9.

TABLE 9. The quantity of omasal contents, containing 46 m.equiv./kg. chloride, needed to dilute 100 g. gastric juice to produce the observed chloride concentration in the abomasum

Series	No. of samples	Range (g.)	Average (g.)
1	10	44–61	48
2	10	26–42	36
3	13	25–40	34
4	13	22–40	33

These analyses support those obtained from the stomach contents of slaughtered animals in that the dilution of gastric juice by omasal contents on a weight for weight basis show that gastric juice forms the larger part of the mixture.

DISCUSSION

There is very little information in the literature on the composition and secretion of the gastric juice of ruminants. This is probably due to the technical difficulty of constructing abomasal pouches. Early investigations of the juice obtained from a Pavlov pouch of the abomasum of the goat (Bichel, 1905; Grosser, 1905) suggested that the acidity was considerably less than that of the dog. An alkaline juice with a very low acidity was obtained after withholding food for 24 hr., and feeding increased the acidity and the rate of secretion. Grosser found values for acidity ranging from 4 to 84 m.equiv./l. and the peptic activity varied with the acidity. Belgowsky (1912) studied the juice secreted by Pavlov pouches of the abomasum of calves and found that while the flow of juice was continuous it increased abruptly after feeding if food had been withheld previously for 16 hr. The quantity of juice collected at different times of the day varied considerably when normal feeding was permitted, without any close relation to feeding. Acidity of the juice ranged from 36 to 98 m.equiv./l. with a maximum of 127 m.equiv./l. The juice, however, was alkaline on occasion. These values found in the calf are slightly less than the values we have found for sheep. Reference to Fig. 6 shows that of the 116 samples examined under normal feeding conditions, 64 lie between 80 and 110 m.equiv./l. and 107 between 50 and 120 m.equiv./l. It is also clear from Fig. 6 that fasting leads to reduced acidity or even to an alkaline juice. The acidity of the juice is less than that of dogs although the chloride concentration is similar. The most remarkable feature was the continuity of secretion and the large volumes produced.

The fact that the rate at which omasal contents pass to the abomasum is not always related to feeding (Phillipson, 1951) suggests that the quantity of juice secreted does not bear any obvious relation to feeding, and our results support this hypothesis. An increased rate of passage to the abomasum was found only after feeding mixtures of meals. The two waves of secretion found when the sheep is fasted does suggest that there is a basic rhythm of secretion to a given feeding regime but that under normal conditions this is often obscured by irregularities in the rate at which food passes to the abdomen and this in turn may be influenced by irregularities in the incidence and duration of rumination. These observations agree with those of Espe & Cannon (1937) who studied the rate of secretion of juice from abomasal pouches in calves. The only constant effect they observed was an increased rate of secretion when milk entered the abomasum. They found no response to psychic stimulation or to sham-feeding, and suggest that the secretion of gastric juice as a result of vagal stimulation is not important in ruminants.

The analytical data confirm previous work that short-chain fatty acids formed in the rumen are absorbed before they reach the small intestine except for small quantities. An assumption is made that water absorption occurs in the omasum. The results suggest that food passes at different speeds through the omasum of different sheep maintained under identical conditions. This can be deduced from a scrutiny of the data given in Table 3. In the two sheep the rumen liquor was practically identical as regards the concentrations of chloride and total volatile acid so that the material entering the omasum was very similar in both animals; subsequent changes found in the material leaving the abomasum must have occurred in the omasum or the abomasum itself. There are two principal explanations that have to be considered. The first is that the fermented food residues passed through the omasum at different speeds and that slow passage leads to greater absorption of water and volatile acid so that the dry-matter concentration in the abomasum was greater and the volatile acid concentration less. This in turn would give a high chloride concentration in the abomasum but total ash and chloride as a proportion of the dry matter would be less. Rapid passage through the omasum would lead to the opposite state of affairs. This hypothesis in fact satisfies the analytical data. The second explanation to be considered is that the volumes of gastric juice secreted by the two sheep differed in both quantity and quality. Calculations, however, based on differences of volume in conjunction with differences in acidity, do not satisfy the analytical data and we may tentatively conclude that the difference between these two sheep was due to difference in rates of passage through the omasum with consequent differences in the quantity of water and volatile acid absorbed.

Aggazzotti (1910), as a result of his somewhat fragmentary experiments, considered that absorption of water occurred from the omasum. The contents of the omasum are well known to contain less water than that of any other part of the stomach and the laminated interior offers a large surface area exposed to the contents so that providing the squamous epithelium is permeable to water, there is no reason why absorption of water should not occur. Garton (1951) from a study of the concentrations of magnesium and phosphorus in the four parts of the stomach of the sheep also concludes that absorption of water occurs in the omasum for both elements are concentrated in this organ.

The dilution of omasal contents when they reach the abomasum indicated by the changes in chloride concentration appears to be large and to be of the order of two parts of gastric juice to one of omasal contents. Garton (1951), however, from the changes in phosphorus concentration suggested that the omasal contents and the gastric juice were mixed in approximately equal parts. A study of the dilution of dry matter from the omasum to the abomasum suggests that both ranges may occur for on post-mortem examination the abomasum dry-matter concentration may vary from one-half to a quarter of that of the omasum (Elsden *et al.* 1946; Phillipson, Green, Reid & Vowles 1949).

The proportion of the gastric mucosa occupied by the pouch of the 'Hollander' type was not greater than 20% of the whole while in one of the sheep in which the partition perforated it was 16% of the whole. As secretion from this type of pouch was approximately a litre a day the total volume of gastric juice secreted by the sheep appears to be considerable, possibly as much as 5–6 l./24 hr., which is of the same order as that postulated for the salivary glands. If this is so then the total volume of fluid including drinking water, which amounts to 2–3 l. daily with sheep fed on a dry ration, exceeds the estimated volume of 10–12 l. leaving the abomasum daily. For this reason we may suppose that absorption of water from the omasum and also possibly from the rumen itself occurs in normally fed sheep.

SUMMARY

1. The concentration of steam-volatile fatty acids in the digesta leaving the abomasum is 7–20 times less than it is in the rumen.

2. The chloride and dry-matter concentrations, when related to each other, are inversely proportional in the digesta leaving the abomasum.

3. The concentrations of chloride in the contents of the rumen, omasum and abomasum increase in that order.

4. The chloride concentration in the gastric juice obtained from two sheep, one with a Hollander and one with a Pavlov pouch of the abomasum, ranged from 141 to 177 m.equiv./l., the average value being 157 m.equiv./l. The average value for a fasting sheep with a Hollander pouch was 153 m.equiv./l. and the average for the same sheep during normal feeding was 158 m.equiv./l.

5. The highest acidity of the gastric juice was 117 m.equiv./l. Under normal circumstances the average value obtained from a Hollander pouch of the abomasum was 86 m.equiv./l. Neutral juice or juice with a low acidity was occasionally secreted.

6. Fasting reduced the acidity of the gastric juice.

7. The ratio of gastric juice to omasal contents calculated from the observed concentrations of chloride in the omasal and abomasal contents and in the gastric juice was approximately 2:1 or greater.

8. There is evidence to suppose that absorption of water occurs from the fermented food residues before they enter the abomasum.

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