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# EFFECTS OF QUANTITY AND QUALITY OF FEED ON GASTRIC SECRETION IN THE SHEEP

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## SUMMARY

Gastric secretion from fundic pouches of the abomasa was studied in sheep. The subjects included animals with simple fundic pouches and others which had in addition an antral pouch or antrectomy. All showed continuous secretion which decreased on restriction of their feed intake. Increases in the volume of secretion, its acid concentration (by as much as 15 m-equiv H<sup>+</sup>/l) and output of pepsin, occurred when the diet was changed to lucerne hay from mixtures of lucerne and wheaten hays. The changes were reversible. Increases when additional feed or better quality feed were made available occurred within 48 hours. More delayed responses were also noted, occurring up to 10 days after better quality feed was provided. The demonstrations of these changes in animals with a pouch of the pyloric antrum and an antrectomy emphasize the importance of stimuli other than those derived from the antrum in the stimulation of gastric secretion and in contributing to secretory responses to changes in diet.

## INTRODUCTION

Gastric secretion in the ruminant is a function of the terminal part of its stomach, the abomasum. This region is the only truly secretory part of the stomach and produces a digestive juice containing HCl and proteolytic enzymes. The physiological mechanisms involved in the control of abomasal secretory activity are complex and include both nervous and hormonal influences (Hill, 1968). An understanding of how feed is utilized by ruminants depends on an appreciation of the contribution made by acid proteolytic digestion in the abomasum and digestion in more caudal parts of the gut as well as digestion due to microbial fermentation in the forestomach. Interest in the role of the abomasum in the digestion of food by ruminants has increased with the development of techniques for protecting feeds from fermentative digestion in the forestomach so that the feed is subjected to gastric and intestinal digestion more akin to that which occurs in animals with a simpler stomach.

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In the ruminant, abomasal secretion is continuous and there is considerable evidence that the amount of feed ingested determines the amount of secretion produced (Masson and Phillipson, 1952; Hill, 1960; Ash, 1961a; McLeay and Titchen, 1970). However, little is known of the effects of the quality of feed on abomasal secretion. Reports made (Kuimov, 1952; Hill, 1960) have been concerned with differences observed in the few hours after feed is first eaten, or have emphasized the variability of secretory responses and the difficulty this has caused in defining the possible effects of different feedstuffs (Ash, 1961a). This report deals with secretory responses of fundic abomasal pouches of sheep fed different amounts of chopped lucerne, and when fed chopped lucerne or a mixture of chopped lucerne and wheaten hays. The nitrogen contents of lucerne and wheaten hays are high and low, respectively (Weston, 1966; Weston and Hogan, 1967).

#### METHODS

Ewes of Australian Romney or Corriedale breeds, or Merino-Border Leicester crosses aged 1 to 2 years and weighing 24 to 45 kg were the experimental subjects. The animals were kept in mobile crates within an animal house and habituated to feeding and management schedules for several weeks before use. They had free access to feed, water and block sodium chloride. The standard diet of chopped lucerne hay was fed to the sheep on an *ad libitum* basis. The food was renewed daily at 10.00-10.30 a.m. and the residues from the previous day dried in an air circulating oven (Labmaster, Drug Houses of Australia Ltd, Sydney) at 100° C for 24 h. The dry matter (DM) intake of each animal was calculated from the dry weight of the feed given, determined by drying a 200 g (wet weight) sample of the fresh food. The particle sizes of the lucerne and wheaten hays were similar to those described by Weston (1966) for lucerne hay and wheaten straw, respectively.

In all animals secretion was obtained from separated innervated pouches of the abomasum prepared from the fundic region as described by McLeay and Titchen (1970). In addition, two animals had the whole antrum isolated into a pouch, and in a third animal the antrum had been removed (antrectomy). Continuity of the alimentary tract in these three animals was restored by abomaso-duodenal anastomoses.

Collections of pouch secretion over a 24-hour period were made with the aid of latex Penrose drainage tubing (McLeay, 1971). The volume of secretion obtained over the previous 24 h was recorded before fresh feed was given each morning. A sample was taken for estimation of the acid and pepsin concentrations following procedures described previously

(McLeay and Titchen, 1970), and the conventions used in that report are followed here. When peptic activity of the samples was determined it was within 24 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 absolute peptic activity in the secretion could be expected to be greater because of losses that may occur with storage (Hunner *et al.*, 1969).

### RESULTS

Secretion from the fundic abomasal pouches of the sheep was continuous. It was reduced, but not abolished, when the pyloric antrum had been formed into a separated pouch or removed. In all of the animals studied (including those subjected to removal or interference with the pyloric antrum) secretion from fundic abomasal pouches was reduced by fasting or restriction of the intake of feed.

When sheep were returned to an *ad libitum* feeding regime after periods of ten or more days on a restricted feed intake there was an increase in the volume of secretion of their fundic pouches within 24 h. The volume and total acid concentration of the secretion, however, showed their greatest increase in the next 24 h. Increases of up to 10 m-equiv H<sup>+</sup>/l have been noted within 48 h of the animals being put on *ad libitum* feeding regimes with further increases of up to 3 m-equiv H<sup>+</sup>/l after a further 7 to 10 days.

These responses contributed to elevated outputs of acid (volume of secretion × concentration of acid in the secretion). Evidence obtained from four animals of such changes when

TABLE 1: PERCENTAGE EFFECTS ON GASTRIC POUCH SECRETION OF CHANGING FROM A RESTRICTED TO AN *AD LIBITUM* FEEDING REGIME

(Values for restricted feeding = 100%)

Sheep	Dry Matter Eaten	Volume	Fundic Pouch Secretion		
			Total Acidity	Total Acid Output*	Pepsin Output*
O	164	166	106	176	171
D1†	142	126	109	137	
F	127	119	104	118	
G‡	137	149	103	151	

\*The arithmetical production of volume and concentration of acid or pepsin.

†This animal had an antral pouch.

‡This animal had been antrectomized.

fed chopped lucerne hay is summarized in Table 1. The figures are taken from observations made on 88 days, on 34 of which the intake of feed had been restricted. In Sheep O (the only animal in this group in which a complete series of measurements of the peptic activity of its pouch secretion was made) there was an increase of the peptic activity, measured as pepsin output/24 h (volume of secretion  $\times$  pepsin concentration) on being returned to feeding on an *ad libitum* basis.

#### NATURE OF THE FEED AND SECRETION FROM FUNDIC POUCHES

A comparison was made of fundic pouch secretion in five animals (three with fundic pouches alone, one of those which also had an antral pouch, and the antrectomized animal) when habituated to diets of lucerne hay, and a mixture of equal parts of chopped lucerne and wheaten hays. Secretion from the fundic pouches was highest when the diet was solely lucerne. The major effect was on the volume of secretion. The greater secretion when animals were given a diet of lucerne was observed both when comparisons were made of secretory responses of animals changed from lucerne to the mixture, and when changed back from the mixture to lucerne.

It was not possible to make a study within the first 48 to 72 h on the development of the effects of changing from lucerne to the other diet. This was because the voluntary intake of feed was initially irregular when the apparently less preferable mixture was provided and thus effects of changes in quality were confused by fluctuations in the quantity eaten. A comparison of the opposite change, that is, to a diet of pure lucerne, was made readily because of the avidity with which it was taken. The volume of secretion increased within 24 h of such a change and within 48 h was markedly raised. The highest volumes of secretion (up to 50% increase) and concentrations of total acid in the secretion (up to 15 m-equiv  $H^+$ /l increase) were attained 7 to 10 days after the animals were changed to being fed solely on lucerne. Pepsin outputs were raised up to 43% on a diet of pure lucerne, although there was either a barely maintained concentration of pepsin in the secretion of the pouches or, in an animal with a simple fundic pouch, a clear reduction in the concentration of pepsin.

#### DISCUSSION

The effects of the quantity of feed on secretion are in accord with previous reports, and have in general been ascribed to alterations in the passage of digesta through the abomasum (Masson and Phillipson, 1952; Hill, 1960; Ash, 1961a). Marked

effects of the quality of feed on secretion were obtained, but the reasons for this remain to be defined. Although dry matter intakes on each diet were comparable, the quality of feed could have affected the flow of digesta into the abomasum and thus its secretion. However, Hogan (1964), using these same diets, has estimated flow from the rumen to be less on lucerne and this would result in correspondingly less secretion.

It would appear, therefore, that stimuli other than flow may be responsible for the differences observed. Such stimuli could include volatile fatty acids, the introduction of which, or of rumen contents, into the abomasum, stimulates its secretion (Ash, 1961b). The possible contribution of these is emphasized by the report (Hogan and Weston, 1967) that the amounts of acetate, propionate, butyrate and valerate in the rumen of sheep fed lucerne hay were twice those of sheep fed wheaten hay.

Another chemical stimulus which deserves consideration is the presence of peptides and amino acids in the abomasal digesta. These have been shown to stimulate gastric secretion in animals with a simple stomach, by release of the hormone gastrin (Elwin and Uvnas, 1966). In this connection it should be noted that the diet with a higher nitrogen content was accompanied by greater amounts of abomasal secretion with higher acid concentrations.

Gastrin is one of the most potent stimulants of HCl known, and is released in particular, but not exclusively, from the antral region of the stomach (Grossman, 1967). In some of the preparations used here the antrum was isolated into a pouch or removed entirely: similar secretory responses observed in these animals, as in animals with intact antra, raise the possibility that gastrin may have been released from other areas of the gut or that other stimuli such as vagal reflexes or more direct reactions may be operative. Whatever the mechanisms involved, it is suggested that elucidation of the nervous and chemical influences resulting from different diets may contribute to a fuller understanding of how feedstuffs are utilized by ruminants and what feedstuffs are best provided to these animals, whether as pasture or in the form of supplements.

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