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Studies on the Alimentary Tract of Merino Sheep in South Africa. XIV.—The effect of some commonly used Antifermentatives on the *in vitro* Formation of Gas in Ruminal Ingesta and its bearing on the Pathogenesis of Bloat.

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INTRODUCTION.

OWING to more intensive farming methods and the increasing use of lucerne as a feed, the problem of bloat in ruminants is assuming great importance in South Africa.

Although this condition has been known the world over for centuries its actual pathogenesis is not yet clearly understood. In a recent exhaustive review of the subject by Cole, Huffman, Kleiber, Olson and Schalk (1945) it is stated:—

> " A view held until recently was that only under conditions in which bloat was common was there an appreciable formation of gas in the rumen. From evidence now at hand, however, the feeding of bloat provoking diets does not necessarily result in greater gas formation—" and later "—the main problem in bloat seems to centre around the expulsion of gas rather than its formation."

Bloat is obviously the result of gas being formed quicker than it is eliminated. Clark and Quin (1945) have shown that sheep can eructate gas (CO_2 or Air) artificially introduced into the rumen at the rate of two litres per minute. As this is undoubtedly far in excess of the possible gas evolution in the rumen, the accumulation in bloat must be associated with failure to eliminate it sufficiently rapidly.

The time-honoured and undoubtedly successful use of turpentine as an antifermentative in the treatment of tympanites does not appear to conform with the above view. It was therefore decided to ascertain at what concentrations some of the more commonly advocated drugs inhibited gas formation in ruminal ingesta.

Method.

Six merino sheep with permanent ruminal fistulae were used, lucerne hay *ad lib.* being fed exclusively. Samples of rumen ingesta were strained through butter muslin and 20 c.c. aliquots of the fluid placed in test tubes. Glucose was added to all tubes to bring about a final concentration of 0·8 per cent. Eight such tubes from each of the six sheep were set up at a time. The first two of each set acted as controls and the agents to be tested were added in the desired concentrations to the remainder, duplicates being used for each treatment. After vigorous shaking Durham fermentation tubes were inverted in the test tubes and the samples incubated in a water bath at 39° C. for two hours. The length of the gas columns was then measured in millimeters.

The average results of numerous such trials are given in Table 1.

Table 1.

Drug.	Therapeutic Dose for Sheep. *	Calculated Concentration in Rumen. †	Concentration Tested.	Percentage Reduction in Gas.
Turpentine......................	15 cc.	1 : 1,000	1 : 1,000 1 : 400 1 : 200 1 : 100	0 3 33 85
Copper Sulphate.................	1 gm.	1 : 15,000	1 : 15,000 1 : 10,000 1 : 4,000	5 62 92
Formalin.......................	4 cc.	1 : 3,750	1 : 4,000 1 : 2,000 1 : 1,000	15 36 70
Phenol.........................	1 gm.	1 : 15,000	1 : 1,000 1 : 400 1 : 200	4 12 49
Proprietary Coal Tar: Prep. A.‡	4 cc.	1 : 3,750	1 : 4,000 1 : 2,000 1 : 1,000	0 17 60
Proprietary Coal Tar: Prep. B.‡	4 cc.	1 : 3,750	1 : 4,000	6

* The maximum doses found in standard text books.

† Calculated on a sheep rumen of 15,000 cc.

‡ These are both proprietary dips or disinfectants containing phenoloids (BP. 200–300°C) and coal tar hydrocarbons largely used by farmers in South Africa for the treatment of bloat. The recommended dose of both for sheep is one drachm.

Considerable variations in the percentage decrease in gas production with given concentrations of the different agents were found among the samples from the various animals. The thicker and more viscid the ingesta the less was gas production affected by the disinfectant. This was doubtless due to the inhibitary action of the organic matter on the agent. The following extracts from the data illustrate this point.

Sheep.	Type of Ingesta.	Date of Collection 28/11/45. Gas Produced.		Date of Collection 4/12/45. Gas Produced.	
		Control.	Plus 1 : 400 Turpentine.	Control.	Plus 1 : 2,000 Prop. Prep. A.
1..................	Viscid.	70	68	63	54
2..................	Viscid.	69	66	37	20
3..................	Watery.	12	0	22	8
4..................	Viscid.	67	70	43	40
5..................	Viscid.	65	64	42	31
6..................	Viscid.	50	46	53	48

As the viscous, high gas producing type of ingesta is invariably found in cases of acute bloat on green feed, it is to be expected that, under these conditions, the agents would be even less effective than indicated in Table 1.

Conclusions.

In view of the above findings it can be assumed that neither turpentine nor the coal tar derivatives have any effect on gas formation in the rumen in therapeutic concentrations. Some other explanation must, therefore, be found for their undoubted beneficial effect in the treatment of acute tympanites and this explanation may help to elucidate the pathogenesis of the condition.

Discussion.

Thick viscid ingesta are often foamy when withdrawn. The foam breaks only slowly on standing and reforms with shaking. The addition of small amounts of turpentine, coal tar preparations or thin oil brings about an immediate and marked change in the physical properties of the ingesta, breaking the foam and preventing its reformation. This clearly indicates that it is through their action on surface tension that these drugs exert their beneficial effect in cases of acute bloat. This explanation is based on the hypothesis that frothing of the ingesta is an important factor in the pathogenesis of the condition.

This theory is by no means new and has been suggested by McCandlish (1937), Olson (1942) and Quin (1943), all of whom incriminated saponin as being the causal factor. Jacobson (1919) fed 19 gm. of lucerne saponin to a sheep without ill-effects and the present author has failed to cause retention of gas artificially introduced into the rumen by previous dosing with saponin.

The frequent occurrence of frothy ingesta in association with acute bloat, accompanied by failure to relieve the condition by passage of the stomach tube or insertion of a canula, is, however, well known to all who have had experience of the condition. The sheep with permanent fistulae at Onderstepoort frequently exhibit marked distention but removal of the cork from the fistula ($\frac{3}{4}$ inch diameter) often fails to relieve the pressure, only a small amount of froth exuding through the tube.

In the review previously cited (Cole *et al*, 1945) Huffman discusses the froth theory of bloat but does not appear to be at all convinced of its validity. He states:—

> "Cole and his co-workers have tapped a number of cows bloated on alfalfa pasture without encountering a case in which the free air space was absent. The fact that often no free gas but, rather, frothy ingesta, escapes when the rumen is tapped is regarded by many as proof that free gas is not present. The cause, conceivably, may be the fact that the free air space is difficult to tap when the rumen is excessively filled. If a free air space exists, it is difficult to understand why frothing would cause bloat. At the moment at which belching occurs there is a dilation of the reticulum and anterior rumen, thus tending to free the cardia for the passage of gas into the oesophagus.

The present author cannot agree with these conclusions.

Gas is removed from the rumen by two methods (i) direct absorption into the blood stream through the rumen wall and subsequent elimination by the lungs and (ii) belching.

The proportion of gas eliminated by the first method is not known but it has frequently been demonstrated that large amounts of carbon dioxide and methane are absorbed through the rumen and that the rate of such absorbtion is dependent on the pressure. The heavy deep breathing seen in non-bloated animals shortly after feeding on lucerne is caused by the absorption of carbon-dioxide from the rumen, the same effect being produced by artificial inflation of the rumen with carbon dioxide (Clark and Quin 1945). If the gas is trapped in a tenacious foam it will not come into contact with the ruminal mucosa and absorption will be retarded.

Unfortunately the mechanism of the eructation reflex in ruminants is not clearly understood. Cole, Mead and Regan (1943) have found a rough correlation between rumination and belching and suggest that the stimulus for the two acts is the same, namely the presence of rough scabrous material in the rumen. This has been proved to be the case in rumination (Schalk and Amadon, 1928). Cole *et al*. (1943) substantiate their hypothesis by the well-known fact that feeding rough hay before lucerne tends to prevent bloat but this can also be explained on the foam theory. The addition of chopped hay to samples of readily foaming ingesta breaks the froth. It is difficult to understand why rumination and belching, although similar mechanically, should both be initiated by the presence of course material in the rumen. Such matter requires rechewing and so it is logical that its presence should cause rumination but as it produces little gas its connection with belching is obscure.

The association between ruminal motility and eructation is also not clear. Clark and Quin (1945) have shown that under certain circumstances sheep can belch gas artificially introduced into the rumen despite ruminal paresis induced by prussic acid. Conversely frequent and strong ruminal contractions are often seen in animals suffering from acute bloat.

Free gas will accumulate in the dorsal sac of the rumen and in order to reach the cardia it must be moved forwards and downwards. The ease with which this can be done will depend on the volume and viscosity of the ingesta. While filling the Durham tubes in the present experiment it was found that, in the case of the thick tenacious samples, vigorous shaking in the inverted position had to be resorted to in order to get the air out of the tubes. The air escaped easily in both the watery samples and the thick samples after the addition of turpentine. The dosing of turpentine will therefore not only break up the foam and increase the volume of free gas available for eructation but also facilitate its transportation within the ruminal mass.

Cole *et al.* (1945) state that belching is facilitated by the administration of turpentine, but the exact mode of action has not yet been determined. They postulate that it may, by its irritant action, initiate the reflex. This is a possibility that cannot be denied but it does not invalidate the beneficial effects on surface tension already discussed.

In the writer's opinion turpentine is still the best drug known for the treatment of acute bloat but as it acts largely through its effect on surface tension superior preparations may yet be found. It is very doubtful whether disinfectants should be introduced into the rumen even if they are effective in reducing gas formation. A properly balanced and active microflora is essential to ruminal digestion and its impairment or destruction may have serious sequence. It is suggested that in milder cases turpentine be dosed, preferably through the stomach tube. In critical cases the canula should be inserted and the turpentine injected through it. This will cause disruption of the foam at the end of the canula and a consequent escape of gas.

Summary.

1. It has been shown that turpentine and two proprietary coal-tar preparations have little or no inhibitary action on gas formation in ruminal ingesta incubated *in vitro* when added in therapeutic concentrations.

2. Very small concentrations of these substances have a marked effect on the physical consistency of the ingesta, raising surface tension and breaking down foam.

3. This affords evidence that it is by their physical action on surface tension that these drugs exert their undoubted beneficial effect in acute bloat.

4. The "foam theory" of the pathogenesis of bloat is discussed.

5. Formalin and copper sulphate may have some inhibitory action on gas formation but the use of ruminal disinfectants cannot be recommended.

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