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The effect on oesophageal groove closure of water and mineral solutions drenched to cows

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ABSTRACT

The fate of mineral solutions when drenched was assessed in cows slaughtered after drenching using a dye visible in gut contents. Seven groups of 10 cows were drenched with water or solutions of magnesium oxide, magnesium chloride, magnesium sulphate, sodium chloride, sodium bicarbonate or zinc oxide in Trial 1. Frequency of closure was higher ($P<0.05$) for sodium bicarbonate (60%) than for magnesium oxide or magnesium chloride (10 to 20%). Five cows drenched with water alone showed bypass of the rumen. In Trial 2 four groups of 6 or 7 cows were drenched with water or solutions containing selenium, Hydromin or copper sulphate. Frequency of closure was higher ($P<0.05$) for copper sulphate (70%) than for water or selenium (0%). The results suggest that bypass of the rumen in response to drenching may contribute to apparent failures of bloat drenches, particularly when certain minerals are added to the drench.

Keywords: dairy cows; oesophageal groove; rumen bypass; abomasum; minerals.

INTRODUCTION

Closure of the oesophageal groove in ruminants is a reflex response triggered by receptors in the back of the mouth (Titchen, 1968). The groove functions in young ruminants to divert milk away from the rumen to the abomasum. Drenching of some salt solutions has resulted in groove closure in adult ruminants. Copper and zinc salts stimulated groove closure in sheep (Clunies Ross, 1936; Smith *et al.*, 1977) and Riek (1954) found that sodium bicarbonate and sodium chloride were effective in stimulating groove closure in more than 90% of 11 month old cattle tested. Magnesium chloride, magnesium sulphate and copper sulphate also caused closure in some animals (Riek,1954).

A range of minerals are commonly drenched to cows on dairy farms in New Zealand, including magnesium oxide or magnesium chloride to prevent hypomagnesaemia, zinc oxide to prevent facial eczema, sodium chloride, sodium bicarbonate, selenium, copper and trace element mixtures. These minerals are often added to bloat drenches. Observations on dairy farms during surveys and farm studies associated with bloat (Carruthers *et al.*, 1987; Carruthers, 1991) suggested that some of the cows which experienced bloat (either dying or needing treatment to relieve bloat) had been drenched prior to the grazing during which the bloat occurred. Failure of the material being administered, the level of challenge relative to the amount drenched or the drenching method may account for these problems. Riek's (1954) data for young cattle suggest that some of the added minerals have the potential to trigger oesophageal groove closure in adult cows. This has serious implications for bloat control as chemicals not reaching the reticulo-rumen would be ineffective, but also for the effects on production of other minerals. The increase in milkfat production attributed to oral administration of magnesium is thought to result from improved fermentation in the reticulo-rumen, and magnesium which bypasses the rumen may elevate blood magnesium but not improve performance (Wilson, 1980). This paper reports on two experiments which used a dye-slaughter technique to determine the route taken through the gut of nine mineral solutions commonly drenched to dairy cows.

EXPERIMENTAL DETAILS

Dye test

A solution of methyl violet (1.25% w/v) was tested in eight cows fistulated in the rumen, to determine whether the dye solution alone triggered the closure of the groove. The cows' rumens were partially emptied or the digesta redistributed so that entry of the drenched material through the cardia could be observed. Each cow was drenched on two occasions with 100 ml water followed immediately by 20 ml dye solution, and the route was observed through the fistula. The water and dye were given using a drench gun with a syringe attached containing the dye. The syringe plunger was depressed as the last of the water was being administered. In all cases, the water and the dye were both observed to enter the rumen.

The dye was administered via syringe because it precipitated when mixed with sodium salts, magnesium chloride or magnesium sulphate. Observations in slaughtered cows established that the dye was visible in gut contents whether precipitated or not and that precipitation did not prevent the dye from staining the groove.

Testing of mineral solutions

Ninety seven Friesian, Jersey and Friesian-Jersey cross cows which were slaughtered at the Ruakura abattoir during January to May 1992 were drenched with one of 10 solutions prior to slaughter. Cows were culls or being slaughtered for other trials. Five cows were rising 2 year olds and the remainder 3 years or older. The first 70 cows (Trial 1) were used to test the following solutions (dose/cow) on slaughter days 1 to 7: water, 100 ml; sodium chloride (NaCl), 20 g plus 80 ml water; sodium bicarbonate ($NaHCO_3$), 40 g plus 80 ml water; magnesium chloride ($MgCl_2.6H_2O$), 100 g plus 50 ml water; magnesium oxide (MgO), 20 g plus 80 ml water; magnesium sulphate ($MgSO_4.7H_2O$), 100 g plus 90 ml water; zinc oxide (ZnO), 10 g plus 50 ml water.

The remaining 27 cows (Trial 2) were used to test the following solutions on slaughter days 7 and 8: water, 100 ml, 7 cows; copper sulphate ($CuSO_4.5H_2O$), 120 mg plus 30 ml water, 7 cows; selenium (Se-24), 2.4 mg plus 30 ml water, 6 cows; a trace element solution (Hydromin, May and Baker) containing selenium (10 g/l), copper (42 g/l), cobalt (4 g/l), zinc (11.2 g/l) and iodine (30 g/l), dosed at 0.15 ml plus 30 ml water, 7 cows.

The magnesium, zinc and trace element dose rates were based on rates and volumes recommended by product manufacturers or veterinarians. The sodium chloride and sodium bicarbonate treatments contained similar concentrations of Na and rates and volumes administered were within the ranges used on commercial farms. Separate drench guns were used for each mineral type (Na, Mg, Zn, Cu, Se, trace element mix). Each cow was drenched about 5 minutes prior to stunning and slaughter. After slaughter the cows were hung from the hind legs and the rumen, reticulum, omasum and abomasum were removed about 20 minutes later. Each organ and the oesophageal groove were examined for evidence of the presence of dye in the digesta or staining of the epithelium. Scoring was as follows: Score 1, dye found in rumen or reticulum digesta only and absent from the omasum and abomasum, groove not stained; Score 2, dye found in the rumen or reticulum and traces in the omasum but not in the abomasum, groove showing a small amount of staining; Score 3, dye found in the rumen, omasum and abomasum, groove stained; Score 4, groove stained and dye predominantly in the omasum and abomasum, but with a trace in the rumen; Score 5, intense staining in the abomasum and dye found in the omasum and groove, dye absent from the rumen.

The dye was more difficult to find in the greater mass of digesta in the rumen and reticulum than in the omasum or abomasum. In a few cases when the groove was not stained and there was no evidence of dye in the omasum or abomasum, the dye was assumed to be in the rumen even though it could not be seen. Drenching of cows and scoring of gut contents were carried out by different people.

Treatments were administered to cows at random in an incomplete block design over 8 days, so that the order of the treatments varied on any given slaughter day. Between four to 24 cows were slaughtered each day. Eighty seven of the cows were from three Dairying Research Corporation Dairies and the remaining ten were from commercial farms. On any given slaughter day the cows were from one or two of the four sources. Conditions to which the cows were subjected (such as feeding pattern, diet) prior to transport to the abattoir were likely to have differed among sources of cows and among days. Seventy six of the cows were accustomed to routine drenching, 11 had not been routinely drenched and the drenching history of ten cows was unknown. All cows were fasted for at least 18 hours prior to slaughter. Water was available prior to slaughter except for one pen of eight cows.

Data analysis

The proportion of cows in which the dye bypassed the rumen (Scores 3, 4 and 5) and the scores for each treatment were analysed within trials using Chi squares or analysis of variance, respectively. Slaughter day was tested but was confounded with source of animals.

RESULTS

In Trial 1 the mean score was higher ($P<0.05$) after drenching with $NaHCO_3$ than with $MgCl_2$ or MgO (Table 1). Mean scores for the other treatments including water were intermediate and did not differ significantly from that of $NaHCO_3$ or from those of $MgCl_2$ and MgO. The number of cows in each treatment group which scored 3 or greater, indicating partial or full bypass of the rumen, is shown in Table 1. Fifty percent of cows drenched with water scored 3 or higher. None of the treatments differed significantly from water in the proportion of cows which bypassed. Using groups of 10 animals, zero or 100% of cows showing bypass would have been required on a treatment for that treatment to have been significantly different from water at 50% bypass.

TABLE 1: The mean scores (and standard error of the difference, SED) and the proportions of cows scoring 3 or greater for treatments drenched in Trials 1 and 2.

Trial	Treatment	Number of cows	Mean score	Number of cows scoring ≥ 3
1	$NaHCO_3$	10	3.1	6
	Water	10	2.5	5
	ZnO	10	2.4	3
	NaCl	10	2.3	5
	$MgSO_4$	10	2.2	4
	$MgCl_2$	10	1.7	2
	MgO	10	1.6	1
	SED		0.6	
2	$CuSO_4$	7	3.0	5
	Hydromin	7	2.3	2
	Se	6	1.5	0
	Water	7	1.3	0
	SED		0.6	

In Trial 2 the mean score was higher ($P<0.05$) after drenching with $CuSO_4$ than with water or Se (Table 1). Mean scores for water, Se and Hydromin were not significantly different. No cows bypassed on water in Trial 2 and this was different ($P<0.05$) from the proportion of cows which bypassed on $CuSO_4$. The mean score and the proportion which bypassed after drenching with water were both higher ($P<0.05$) in Trial 1 than in Trial 2.

When the data were analysed over both trials, there were significant differences among days (confounded with source of animals), although within each trial, day had no significant effect on mean score. Averaged over all days the mean score for the water treatment was 2.0 and 30% of the cows drenched with water scored 3 or greater. The mean score for $NaHCO_3$ was higher ($P<0.05$) than that of water averaged over all days.

DISCUSSION

$NaHCO_3$ and $CuSO_4$ appeared to be the most potent of the mineral solutions tested in their stimulation of the reflex closure of the oesophageal groove, but in some cows water alone triggered bypass of the rumen. The act of drenching may be sufficient stimulus to trigger groove closure in some animals.

The frequencies of bypass observed for $NaHCO_3$ and $CuSO_4$ were lower than those observed for $NaHCO_3$ and NaCl in yearling cattle (Riek, 1954). In the present study the mean score for NaCl did not differ significantly from either $NaHCO_3$ or water, so it was not clear whether the likelihood of bypass was increased by the NaCl treatment. The frequency of bypass on water differed among trials but taken over the three trials (including the preliminary dye test), 5 of 25 cows (20%) drenched with water showed bypass of the rumen. This level of bypass, apparently in response to the act of drenching, could pose significant problems were it to occur with bloat drenching or in an experimental situation where treatments are assumed to enter the rumen. There have been other reports of groove closure in sheep and calves drenched with water (Clunies Ross, 1931; Riek, 1954), and ruminal bypass has also been recorded in cows when drinking water (Woodford *et al.*, 1984), but the frequency expected in adult cattle and the factors affecting it have not been investigated in any detail. Failure of drenching to provide full control of bloat is a substantial problem in some herds and a sporadic problem in others; reflex closure of the groove in response to drenching alone or to an added mineral could contribute to these problems. Whether addition of $NaHCO_3$ to trough water increases the likelihood of bypass during drinking is not known, but some farmers add both bloat preventatives and $NaHCO_3$ to trough water.

Fasting may have increased the bypass frequency compared to animals not fasted. Clunies Ross (1931) reported that withholding water and food from sheep for 0, 18-24 and 40 hours resulted in 27, 50 and 79%, respectively, of animals bypassing the rumen when drenched with water and dye, although Watson (1941) concluded that withholding food and water from sheep for up to 51 hours had no effect on bypass rate. Monnig & Quinn (1933, 1935) concluded that fluidity of rumen contents, but not starvation, affected the frequency of closure in sheep. Starvation tends to lower the digesta dry matter content, however, and thus the dry matter content of rumen digesta was likely to have been lower in the abattoir cows than in those used for the dye test.

The trials reported here indicated which minerals commonly used on farms may increase frequency of bypass. The minerals were not tested specifically with bloat drenches but until data indicate otherwise, farmers should avoid adding $NaHCO_3$, $CuSO_4$, and possibly NaCl to bloat drenches in order to minimise the likelihood of bypass occurring. The minerals were tested at one concentration and one volume only; there is evidence that increasing the concentrations may evoke a greater response (Smith *et al.*, 1977). An alternative technique to assess bypass is required for use in cows not fasted, for determining repeatability within cow and for testing bloat drenches without additives and with varying concentrations of mineral additions. The chemical type, dye type and dilution rate of bloat drenches also varies as does total volume drenched after inclusion of additives. The effect of habituation to drenching on closure has also not been assessed, but several studies on sheep have demonstrated the effects of training on the oesophageal groove reflex (Orskov, 1975).

The possibility that bypass may occur in response to drenching alone, or that the frequency may be higher when animals are fasted or particular minerals are given, should be considered when drenching experimental treatments and in farm situations when it is important that the drenched material enters the reticulo-rumen.

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