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The effect of sodium bicarbonate on yield and composition of milk from grazing cows in early lactation

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ABSTRACT

Four trials in early to mid lactation investigated the effect of supplementation with sodium bicarbonate on milk production from cows grazing pasture. In Trial 1, 3 groups of 14 cows received 0, 100 g or 200 g $NaHCO_3$/cow/day for 28 days. Trial 2 assessed whether any effects of sodium bicarbonate were due to sodium by comparing no supplement, 200 g $NaHCO_3$/cow/day and 140 g NaCl with three groups of 20 cows for 28 days. In both trials treatments were administered by drenching at each milking. Trial 3 assessed the importance of method of administration. Treatments of no supplement, 100 g $NaHCO_3$/cow/day by drenching at the morning milking, or 100 g $NaHCO_3$/cow/day in the drinking water were administered to 3 groups of 20 cows, during three 21 day periods according to a latin square design. Trial 4 compared rates of 0, 50, and 100 g NaHCO3 via drinking water with 3 groups of 18 cows for 21 days.

In Trial 1 milk yield and protein yield were significantly reduced ($P<0.10$) by drenching 200 g $NaHCO_3$/day, compared to the control cows (14.7 vs 15.3 kg milk/cow/day). The lower dose rate did not affect milk yield or composition. In Trials 2 and 4, none of the treatments significantly affected milk solids yields. Milk, protein and lactose yields from cows on the trough treatment were higher than those for control and drenched cows in Trial 3. Plasma magnesium was lower in drenched cows than in control or trough treatment cows.

Keywords Dairy cows, milk production, sodium bicarbonate, pasture, trough treatment, drenching.

INTRODUCTION

Sodium bicarbonate is widely used in concentrate rations overseas to increase pH in the rumen after feeding and buffer the acids produced during fermentation on diets high in grain and low in roughage. Level of inclusion has ranged from about 0.7 to 2.5% of total dry matter intake. The effects of sodium bicarbonate on milk solids production have been inconsistent, with reported improvements in milk yield but not fat content (Kilmer *et al.*, 1980; Fisher and McKay 1983), fat content but not milk yield (Rogers *et al.*, 1982; Snyder *et al.*, 1983; Solorzano *et al.*, 1989), or no effect on either milk yield or fat content (Donker and Marx, 1985). Some farmers in New Zealand have claimed improved milk solids yields through supplementing cows grazed on pasture with sodium bicarbonate in the drinking water (Dairy Exporter, 1990). The rates of inclusion vary but in recent years have tended to be lower, at about 0.2 to 0.7% of dry matter intake, than those used in concentrate diets.

The effect on milk solids production of supplementing cows with sodium bicarbonate was assessed in four trials which included comparisons of rates of supplementation and method of administration.

MATERIALS AND METHODS

Four trials were carried out in early to mid lactation. Trials 1 and 2 were in 1984/85 and Trials 3 and 4 in the 1990/91 season. Trial 1 compared 3 levels of sodium bicarbonate when given by drenching. Trial 2 compared sodium bicarbonate and sodium chloride to assess whether any effects observed in Trial 1 were due to sodium rather than to bicarbonate. Trial 3 assessed whether sodium bicarbonate was more effective if administered through the drinking water than by drenching. Three rates of administration via drinking water were compared in Trial 4.

Treatments and Cows

Trial 1

Trial 1 involved three groups of 14 mixed age Jersey cows which had been lactating for an average of 68 days at the start of the trial. A uniformity period of 7 days was followed by a treatment period of 28 days.

The treatments were:

- control (no drench)
- 100 g $NaHCO_3$/cow/day by drenching
- 200 g $NaHCO_3$/cow/day by drenching

The sodium bicarbonate and sodium chloride treatments were drenched as a slurry with half of the daily dose given in 100 mls water at each milking. Cows were grazed as one herd.

Trial 2

Trial 2 involved 60 mixed age Jersey cows which on average had been lactating for 53 days at the start of the trial. A 7 day uniformity period was followed by 28 days during which treatments were applied.

The treatments were:

- control (no drench)
- 200 g $NaHCO_3$/cow/day by drenching
- 140 g NaCl/cow/day by drenching

The two drench treatments provided equal amounts of sodium (54 g/day) and half of this amount was administered in 100 mls water at each milking. The treatments were superimposed on a farmlet trial involving different stocking rates. Each treatment group was balanced with 5 cows from each of 4 herds stocked at 2.8, 3.3, 3.8 and 4.3 cows/ha.

Trial 3

Trial 3 involved 3 groups of 20 mixed age Friesian cows in early lactation. Treatments were administered to each group according to a latin square design, with the first 21 day period starting 41 days after calving.

The treatments were:

- control (no supplement)
- 100 g $NaHCO_3$/cow/day drenched at the morning milking
- 100 g $NaHCO_3$/cow/day (nominal rate) administered in the drinking water.

The sodium bicarbonate was drenched as a slurry in 100 mls water. The cows were grazed as 3 separate herds with each being offered 0.27 ha of fresh pasture after the morning milking. Pre-grazing herbage mass averaged 2700 kg dry matter/ha. The only source of water for the cows on the trough treatment was a portable tank and trough placed within the area of pasture being grazed. The tank contained a solution of sodium bicarbonate sufficient to provide 100 g/cow/day and an allowance for a full trough remaining. An estimate of the amount of water likely to be drunk each day was made based on previous day's intakes and on the weather, and the amount of water added to the tank was adjusted accordingly. Thus the concentration of sodium bicarbonate varied from day to day depending on expected water intake. The volume drunk each day by each treatment group was estimated using flow meters inserted in the trough inlet lines.

Trial 4

Trial 4 involved 3 groups of 18 mixed age Friesian and Jersey cows which had been lactating for 62 days at the start of the trial.

The treatments were:

- control (no supplement)
- 50g $NaHCO_3$/cow/day (nominal rate) administered in the drinking water
- 100g $NaHCO_3$/cow/day (nominal rate) administered in the drinking water.

Treatments were administered for 21 days from mid October. The cows were grazed as 3 separate herds and were offered 0.25 ha of fresh pasture after the morning milking. Pre-grazing herbage mass averaged 2900 kg dry matter/ha. Details of trough treatments and measurement of fluid intakes were as described for Trial 3, with sodium bicarbonate solutions adjusted to provide either 50 or 100 g/cow/day.

In all trials the cows were drenched with bloat preventatives once or twice daily and magnesium chloride once daily to prevent bloat and hypomagnesaemia.

Measurements

In Trials 1 and 2 milk weights for individual cows were measured at 10 consecutive milkings each week. Aliquot samples for fat, protein and lactose content were taken from four consecutive milkings each week. Milk yield and fat, protein and lactose contents were measured at 4 milkings each week in Trial 3 and at 6 milkings each week in Trial 4. Plasma magnesium of all cows in Trial 3 was measured on 2 samples taken 7 days prior to the start of the trial and on one occasion during the third week of each treatment period.

Statistical Analysis

In all trials the treatment groups were balanced for calving date, milk fat yield and age of cow. Treatment effects were assessed over the final 2 or 3 weeks of each period, allowing the first week of each treatment period as an adaptation period. Milk yield and composition during the 2 weeks preceding each trial were used as covariates in Trials 1, 2, and 4. Data in Trial 3 were analysed using a latin square analysis. In all trials variation among animals within group was used to estimate error variance. Means and the standard error of the difference between means are presented with the following levels of significance: ns not significant; + P<0.10; * P<0.05; ** P<0.01; *** P<0.001

RESULTS

Drenching with 200 g sodium bicarbonate cow/day reduced the yields of milk, protein and lactose in Trial 1 but not in Trial 2 (Tables 1 and 2). No effect of sodium on milk yield or composition was demonstrated in Trial 2, except that lactose percent was higher in milk from cows drenched with sodium chloride than control cows. Drenching 100 g sodium bicarbonate /cow/day had no effect on production in Trial 1 (Table 1).

Adding sodium bicarbonate to the water supply increased milk yield and yields of protein and lactose compared to control and drenched cows in Trial 3 (Table 3). Protein and lactose percents were lower for drenched cows than for control and trough treatment cows, but there were no significant differences in yield of protein or lactose. Responses by 1 of the 3 herds to the trough treatment resulted in significant herd by treatment interactions for fat percent (P<0.001) and fat yield (P<0.01). On average the plasma magnesium values were 6% lower for drenched cows than for control cows (Table 3) but this response was also not consistent for all herds.

TABLE 1 The effect of drenching 0, 100 or 200 g $NaHCO_3$/cow/day on milk, fat, protein and lactose yields (kg/cow/day) and milk composition (Trial 1).

	Treatment				
	0	100	200	sed	sig.
Milk yield	15.3	15.3	14.7	0.3	+
Fat %	5.34	5.46	5.36	0.10	ns
Protein %	3.77	3.77	3.75	0.05	ns
Lactose %	5.40	5.41	5.36	0.03	ns
Fat yield	0.81	0.82	0.79	0.02	ns
Protein yield	0.57	0.57	0.55	0.01	+
Lactose yield	0.82	0.82	0.79	0.02	*

TABLE 2 The effect of no supplement, 200 g $NaHCO_3$/cow/day or 140 g NaCl/cow/day on milk yield (kg/cow/day) and composition (Trial 2).

	Treatment				
	control	$NaHCO_3$	NaCl	sed	sig.
Milk yield	12.7	12.6	12.9	0.3	ns
Fat %	5.63	5.48	5.70	0.16	ns
Protein %	3.93	3.99	4.00	0.04	ns
Lactose %	5.17	5.24	5.32	0.07	+

Neither 50 nor 100 g of sodium bicarbonate affected milk yield or composition in Trial 4 compared to unsupplemented cows (Table 4).

The actual intakes of sodium bicarbonate in trough treatment groups in Trials 3 and 4 varied from day to day and averaged less than the nominated rates because cows did not drink on wet days. In Trial 3 the intakes of sodium bicarbonate averaged 83.6, 89.7 and 86.3 g/cow during the final 2 weeks of periods 1, 2 and

3, respectively. Daily intake of sodium bicarbonate ranged from 6 g to 110 g/cow. Fluid intake was higher for trough treatment cows than for drench or control cows (36, 29 and 28 l, respectively, sed 1.3). Daily fluid intake ranged from zero for control and drench groups to 58 l/cow, recorded for the trough treatment group. The lowest daily intake/cow by the trough treatment group was 1 l.

TABLE 3 The effect of no $NaHCO_3$, 100 g $NaHCO_3$/cow/day administered in the drinking water or 100 g $NaHCO_3$/cow/day administered by drenching on milk, fat, protein and lactose yields (kg/cow/day), milk composition and plasma magnesium (mmol/l) (Trial 3).

	Treatment				
	control	water	drench	sed	sig.
Milk yield	20.1	20.4	19.9	0.2	**
Fat %	4.50	4.49	4.49	0.03	ns
Protein %	3.48	3.50	3.45	0.02	*
Lactose %	4.66	4.70	4.66	0.01	***
Fat yield	0.90	0.91	0.89	0.01	ns
Protein yield	0.70	0.72	0.69	0.01	***
Lactose yield	0.93	0.96	0.93	0.01	***
Plasma Mg	1.02	1.01	0.96	0.02	***

In Trial 4 the daily intake/cow of sodium bicarbonate for the 50 g and 100 g treatment groups averaged 42.4 and 94.0 g/cow, respectively. Intakes ranged from 8 to 58 g/cow and 37 to 119 g/cow during the 14 days over which the treatment effects were assessed. Fluid intakes averaged 25, 26 and 29 l/cow for control, 50 g and 100 g treatment groups, respectively.

TABLE 4 The effect of 0, 50 or 100 g $NaHCO_3$/cow/day administered in the drinking water on milk yield (kg/cow/day) and composition (Trial 4).

	Treatment				
	0	50	100	sed	sig.
Milk yield	17.5	17.9	17.2	0.5	ns
Fat %	5.20	5.19	5.29	0.12	ns
Protein %	3.82	3.79	3.83	0.05	ns
Lactose %	4.81	4.82	4.81	0.04	ns

DISCUSSION

Inconsistent effects of sodium bicarbonate on milk yield or yields of fat and protein were demonstrated. The results of Trial 1 indicate that cow performance may on occasion be reduced by high doses of sodium bicarbonate. Milk and protein yields were increased by administering 100 g sodium bicarbonate in drinking water in Trial 3 but not in Trial 4. The effect on protein yield in Trial 3 appeared to result from the increase in milk yield rather than from an increase in percent protein, although fat yield was not improved. Rates of sodium bicarbonate used by farmers in New Zealand have been reported to vary from 20 to 80 g/cow, depending on the time of year and pasture conditions. It seems unlikely that an inappropriate dose rate was responsible for the lack of beneficial effects in Trial 4 since no response was obtained with either 50 or 100 g of sodium bicarbonate administered via the water trough.

At December 1990 prices of 186.44 c/kg fat, 342.25 c/kg protein and a charge of 3.75 c/l milk, the value to the farmer of the milk produced in Trial 3 was $3.32, 3.39, and 3.27/cow/day for control, trough treatment and drenched cows, respectively. The cost of sodium bicarbonate ranges from about 8.4 to 15 c/100 g, depending on product source, therefore the cost of supplementation was not met by the 7 c/cow advantage to trough treatment.

Inconsistent responses in milk and fat yields to sodium bicarbonate are also reported in cows on high grain diets. On these diets, sodium bicarbonate is used to prevent decreases in ruminal pH and acetate:propionate ratio that are associated with low milk fat syndrome. These rumen conditions and the low milk fat syndrome are not associated with pasture diets. Sodium bicarbonate may also increase outflow of digesta from the rumen and decrease mean retention time in the rumen (Okeke *et al.*, 1983), and supplementation has been used in an attempt to improve protein utilisation on high energy diets. Results here are also inconsistent, with some studies showing little effect of sodium bicarbonate on protein digestibility or bypass from the rumen (Okeke *et al.*, 1983; Snyder *et al.*, 1983).

Plasma magnesium was lower compared to control cows when sodium bicarbonate was administered by drenching but not by trough treatment. A reduced serum magnesium value in sodium bicarbonate

supplemented cows has been previously observed (Rogers *et al.*, 1985). The reason for the difference between the two treatments in their effect on plasma magnesium is not apparent, and the interaction observed suggests further observations are necessary to assess the response. Possibly a single large dose of sodium bicarbonate affects magnesium absorption in the rumen to a greater extent than smaller doses during the day, although intake by cattle of pasture fertilised with NaCl was associated with lower magnesium values than was unfertilised pasture (Smith *et al.*, 1983).

Any reported rate of intake when sodium bicarbonate is administered through the farm water supply will be approximate because neither the water intake of the herd nor the variation from day to day will be known. Water intake was increased by about 26% when sodium bicarbonate was added to the drinking water in Trial 3 but was less affected in Trial 4. The reason for this was not apparent but may be associated with the difference between the two trials in response of milk yield. Users of sodium bicarbonate should ensure that the water supply is adequate to cope with a possible increase in demand.

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