EFFECTS OF BUFFER SALTS ON FEED INTAKE, GROWTH RATE, RUMEN pH AND ACID-BASE BALANCE IN CALVES

R.C. KELLAWAY*, T. GRANT+ and G.T. HARGREAVE*

Summary

Inclusion of 2% $NaHCO_3$ + 2% Na_2HPO_4 or 4% $NaHCO_3$ in calf diets increased feed intake and growth rates. When other sources of Na were omitted, inclusion of 1% $NaHCO_3$ + 1% Na_2HPO_4 did not increase feed intake or growth rate. The median rumen pH was 5.3 and 5.8 on control and 4% $NaHCO_3$ diets respectively. Base excess in the blood was LO.12 and 9.45 m-equiv./l on control and 4% NaHCO diets respectively; blood pH was maintained within the normal range oa the latter diet by a compensatory increase in pCO_2.

I. INTRODUCTION

Saliva production per unit food eaten is much lower in young ruminants (Wilson and Tribe 1961) than in adults (Balch 1958). $NaHCO_3$ and Na_2HPO_4, present in roughly equal amounts, are the major salts in saliva (Kay 1960). Inclusion of $NaHCO_3$ and Na_2HPO_4 in concentrate pellets fed to young calves resulted in substantial increases in food intake and growth rate (Kellaway, Grant and Chudleigh 1973). This paper reports further on the effects of including buffer salts in concentrate pellets fed to calves.

II. MATERIALS AND METHODS

Friesian bull calves were used in all experiments. In Expt 1 calves were given milk replacer up to five weeks of age, as described previously (Kellaway, Grant and Chudleigh 1973). From one week of age, they were offered straw chaff and one of three types of concentrate pellets which were based on barley grain. The pellets offered were control (A), 4% mixed buffer salts (2% $NaHCO_3$ + 2% Na_2HPO_4) (B) and 4% $NaHCO_3$ (C). Diets A and B were similar to those fed previously (Kellaway, Grant and Chudleigh 1973) whereas diet C differed only in respect of the buffer salt; they contained 5.5, 17.4 and 16.4 g Na/kg dry matter respectively. Sixteen calves were allocated to each diet, and these were group-fed in pens, each of which contained eight calves.

In Expt 2, calves were reared on one of two systems; weaning at 5 weeks of age and keeping on high protein pellets up to ten weeks of age (standard), or weaning at four weeks of age and transferring from high to low protein pellets between eight and ten weeks of age (early). The feeding regime up to four weeks of age was the same as in Expt 1 except that the pellets offered were control (A) and 2% mixed buffer salts (1% $NaHCO_3$ + 1% Na_2HPO_4) (D) which contained no NaCl and Na_2SO_4. Both diets contained about 6 g Na/kg dry matter. Sixteen calves were allocated to each of the four treatments and these were group-fed in pens each of which contained eight calves.

Individual live weights and feed intakes for each pen were recorded weekly. Analyses of variance were carried out only on liveweight data

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* Dairy Research Unit, Department of Animal Husbandry, University of Sydney, Camden, N.S.W. 2570.

\+ Veanavite Pty. Ltd., Cowra, N.S.W. 2794.

for which individual animal observations were available.

In Expt 3, diets A and C, together with straw chaff were each fed to four calves fitted with rumen cannulae. Jugular blood, collected weekly for five weeks after weaning at five weeks of age, was analysed for acid-base balance, using the procedures described by Billitzer and Jarrett (1970). Rumen pH was measured continuously for two 24 h periods, at six and eleven weeks of age respectively.

III. RESULTS AND DISCUSSION

In Expt 1, the intake of pellets after weaning on diets A and B was 30% lower than that recorded with similar diets in a previous experiment (Kellaway, Grant and Chudleigh 1973). The pellets were of similar formulation and chemical composition, but may have differed in hardness. Despite this, intakes of diets containing buffer salts (B and C) were higher than that of the control diet (A), which resulted in higher growth rates, pre- and post-weaning, on diets B and C than on diet A (Table 1). It appears that NaHCO alone was as effective in increasing intake as the mixture of Na_2HPO_4 ana $NaHCO_3$. $NaHCO_3$ is considerably cheaper than Na_2HPO_4.

TABLE1

Intake of pellets and chaff, together with growth rates for calves on control (A), 4% mixed buffers (B) and 4% NaHCO3 (C) diets

	Diets A	Diets B	Diets C	$P<0.05$
Pre-weaning (1-5 weeks of age)				
Intake (kg/day) - pellets	0.27	0.33	0.37	
- chaff	0.03	0.03	0.03	
Growth rate (kg/day)	0.46	0.56	0.51	B & C > A; B>C
Post-weaning (6-10 weeks of age)				
Intake (kg/day)- pellets	1.54	1.84	1.73	
- chaff	0.13	0.24	0.22	
Growth rate (kg/day)	0.51	0.61	0.60	B & C > A

The main effect of Expt 2 was that the total intake of pellets was 177 and 156 kg on the standard and early weaning systems respectively. The growth rate up to ten weeks of age was significantly lower on the early weaning system (Table 2).

Two per cent mixed buffer salts were included in diet D because we found previously that 2 and 4% levels of inclusion were equally effective in increasing feed intake and growth rate (Kellaway, Grant and Chudleigh 1973). NaCl and Na_2SO_4 were omitted in order to reduce the sodium concentration because the currently recommended level is 1 g Na/kg dry matter (National Research Council 1971). There was no difference in feed intake between the control diet (A) and the diet containing buffer salts (D) and growth rates were similar on the two diets. This suggests that the responses obtained in our earlier work (Kellaway, Grant and Chudleigh 1973) and Expt 1 were attributable to Na rather than the buffer anions. Saville et al. (1973) found that at 6-7 g Na/kg dry matter, NaCl and buffer salts were equally effective in increasing the intake of wheat alone, which contained 0.02 g Na/kg dry matter. High levels of Na in the diet either as NaCl (Hemsley, Hogan and Weston 1975) or mixed buffer salts

TABLE 2

Intake of pellets and chaff, together with growth rates for calves fed control (A) or 2% mixed buffer (D) diets on standard or early rearing systems

	Rearing system	Weeks of age	Diets A	D	P<0.001
Intake (kg/day)					
Pellets	Standard	2 - 5	0.36	0.47	
		6 - 10	2.02	2.38	
	Early	2 - 4	0.26	0.27	
		5 - 8	1.46	1.57	
		9 - 10	2.29	1.99	
Chaff	Standard	2 - 5	0.05	0.05	
		6 - 10	0.25	0.18	
	Early	2 - 4	0.03	0.04	
		5 - 8	0.14	0.16	
		9 - 10	0.18	0.19	
Growth rate (kg/day)					
	Standard	1 - 10	0.62	0.65	Std > Early
	Early	1 - 10	0.52	0.52	

(Harrison et al. 1975) increased rumen dilution rate and reduced the proportion of organic matter digested in the rumen. An increased flow rate of digesta through the rumen could minimise physical limitations to intake. Although the intake of concentrate diets in adult cattle is limited by chemical rather than physical factors (Baumgardt 1970) the small size of the rumen in calves normally may impose physical limitations to the intake of concentrate diets.

The acid-base measurements in Expt 3 (table 3) indicate that with 4% $NaHCO_3$ in the diet there was a large base excess, which was attributable to the bicarbonate. Although this caused an elevation in blood pH, there was a compensatory increase in pCO_2 which resulted in blood pH remaining within the normal range for calves (Donawick and Baue 1968). Rumen pH in these calves (table 4) was markedly affected by diet. The median pH values were 5.3 and 5.8 on the control diet and the diet containing 4% $NaHCO_3$ respectively. These pH values were similar to those reported by Kay, Fell and Boyne (1969) for steers fed barley and barley plus 7.5% $NaHCO_3$ respectively. They found extensive pathological changes in the rumen wall of steers on the barley diet which were absent from steers given the NaHCO supplement. It seems likely that the higher intake which we observed an diet (C) was at least partly mediated by the higher rumen pH

TABLE 3

Acid-base balance in calves on control (A) and 4% $NaHCO_3$ (C) diets, each value the mean of 6 measurements on each of 4 calves

	Diet A	C	P
Base excess (m-equiv./l)	-0.12	9.45	<0.001
Actual pCO_2 (mm Hg)	45.6	52.5	<0.001
Actual pH	7.36	7.44	<0.001
Actual HCO_3 (m-equiv./l)	25.4	35.4	<0.001

TABLE 4

Rumen pH in calves on control (A) and 4% $NaHCO_3$ (C) diets, recorded at 6 and 11 weeks of age, expressed as percentage of 24 h period within specified pH range

Age	Diet	pH range 4.0-4.5	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.0
6 weeks	A	0.88	5.53	49.05	40.48	4.08	0.00
	C	0.00	1.00	11.83	41.05	42.20	3.93
11 weeks	A	2.35	8.40	52.15	28.20	7.80	1.10
	C	0.00	0.00	9.13	39.60	35.67	15.60

on this diet which would have provided more favourable conditions for ruminal microbiota, as well as reducing the possible incidence of pathological lesions in the rumen wall.

Current collaborative studies aim to define the intake response curves with different levels of NaCl and $NaHCO_3$ in the diet, and also to elucidate the response mechanisms.

IV. ACKNOWLEDGMENTS

We would like to thank Mr. Phillip Grant for care and management of the calves and Miss S. Faber for technical assistance.

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