
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Changes in the salivary sodium:potassium ratio in lactating cows in response to changes in sodium intake

N. R. TOWERS

Ruakura Animal Research Station
Ministry of Agriculture and Fisheries, Hamilton

ABSTRACT

The rate at which the Na:K ratio of parotid saliva changes with changes in Na intake has been determined in lactating dairy cows. The salivary Na:K ratio of cows with an already marginal Na status fell immediately the animals were transferred to a Na deficient diet. Similarly the Na:K ratio of Na deficient cows increased within days of Na supplementation reaching maximum levels after 2 weeks. The mean Na:K ratio for fully sodium replete cows was about 24 to 28:1, but there was considerable variation in the values for individual animals.

Keywords Parotid saliva; sodium:potassium ratio; lactating dairy cows; sodium intake

INTRODUCTION

Following a survey of pasture Na concentrations Smith and Middleton (1978) have estimated that, depending on the district, from 30 to 70% of lactating dairy cows may have an inadequate Na intake. Thus a diagnostic test identifying cows with a production limiting suboptimal Na intake is required to substantiate these estimates but such a test is not currently available.

The Na:K ratio of parotid saliva responds to changes in Na intake (Denton, 1956; Dobson *et al.*, 1960) and has been suggested as a useful measure of the Na status of grazing livestock (Skydsgaard, 1967; Bott *et al.*, 1964).

However, while the literature contains some data on the Na:K ratios of Na replete and deficient dairy cows (Kemp *et al.*, 1972; Leche, 1977; Davison *et al.*, 1980), little is known of how quickly changes in Na intake are reflected in the Na:K ratio of parotid saliva. Nor is there an established relationship between the Na:K ratio and the presence of Na dependent production responses. As a preliminary to establishing this relationship the rate at which changes in Na intake are reflected in the salivary Na:K ratio has been examined.

METHODS

Thirty-two cows in late lactation were switched from grazing a predominantly perennial ryegrass and white clover pasture to a low Na diet consisting mainly of greenfeed maize and hybrid sorghum (Sudax). Lucerne or red clover constituted about 10% of the diet, while mixed pasture provided about 5% of the total dry matter intake. The overall mean Na content of the low Na diet was estimated to be 0.3 g Na/kg DM, sufficient to provide 20 to 25% of the estimated requirement. Saliva samples from 15 cows chosen at random were collected at weekly intervals to monitor changes in salivary Na and K concentrations.

After 5 weeks on the low Na diet the animals were divided into 4 groups of 8 (balanced for milk yield and live weight). Three groups were given daily supplements of NaCl to provide 3, 6 or 12 g Na/d after the evening milking. The fourth group was retained as a low Na control. Saliva samples were collected twice weekly after the morning milking from all cows for the following 3 weeks.

After 3 weeks Na supplementation the Na status of the cows was further manipulated by switching the diet back to a mixed pasture thereby increasing the basal dietary intake from about 1.5 to 2 g/d to 8 to 10 g/d, drying off the cows to reduce the Na requirement and by withdrawing Na supplements. Saliva samples were collected at weekly intervals and then 2 weeks and 2 months after all Na supplements were withdrawn.

Saliva samples were collected in triplicate by placing an acid washed Na-free swab between the cheek and the upper molars near the duct from the parotid saliva gland. The weight of saliva collected was determined by weighing the swab, in its sample jar, before and after the collection.

Electrolyte concentrations were determined by atomic absorption spectrometry after extraction of the swab with 5% v:v HCl.

RESULTS AND DISCUSSION

At the start of the trial the mean Na:K ratio was 17.2, a value lower than reported for Na replete beef and dairy cattle, suggesting the herd may already have had an inadequate Na intake. Following the change in diet the Na:K ratio fell rapidly and minimum values were reached after 2 weeks on the low Na diet (Fig. 1). A notable feature was the very wide range in individual values found within the herd.

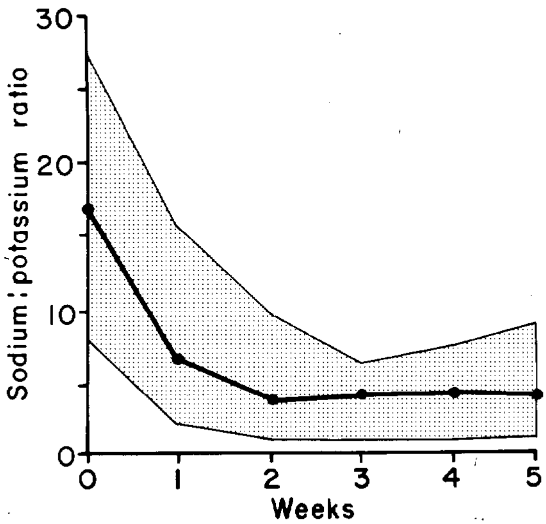

FIG. 1 Changes in the mean Na:K ratio in parotid saliva following a change from a high Na to a low Na diet. Shaded area shows range of results.

Following Na supplementation the salivary Na and K levels again responded rapidly, with the group means already tending to diverge after 4 days and being significantly different after 1 week of supplementation. These changes were reflected in rapid changes in the Na:K ratio which increased in a dose dependent manner (Fig. 2). Maximal effects of supplementation were achieved after 2 weeks, thereafter the mean Na:K ratios tended to plateau at levels dependent on the dose rate.

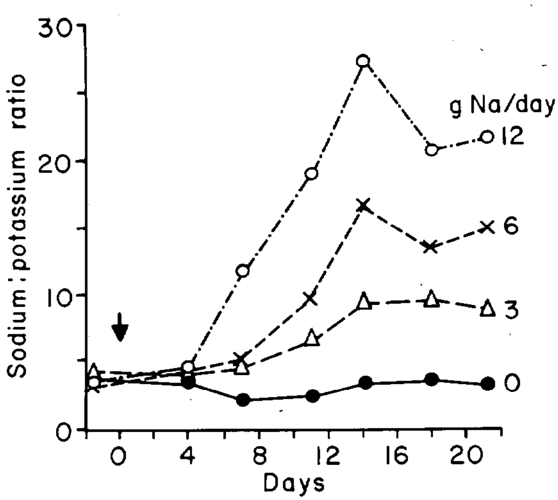

FIG. 2 Changes in the mean Na:K ratio in parotid saliva following Na supplementation of Na deficient lactating cows.

Subsequent changes in Na status, caused by returning the cows to pasture, drying-off or by withdrawing Na supplements also affected the Na and K concentration of parotid saliva. Each such change in Na intake or status was reflected in a change in the Na:K ratio observed except where the Na intake, both before and after the change in status, was high and clearly exceeded the Na requirement.

The relationship between the observed Na:K ratio and production levels could not be examined in this trial. The largely maize and sorghum diet consumed by the cattle was inadequate to maintain normal lactation and the milk yields of all groups were similar. Production of all groups declined markedly while on the low Na diet, but recovered after the animals returned to an all grass diet.

However the relationship between the observed ratio and the estimated Na requirement of the cows was investigated. For this purpose the Na requirement was estimated in 2 ways.

First from the data itself. Morris and Peterson (1975) following a similar study with sheep, suggested that the relationship between the Na:K ratio and Na intake was rectilinear, with the Na:K ratio initially increasing linearly with the Na intake to a maximum value above which it does not rise despite further increases in Na intake. They suggest that the intersection of the 2 linear regressions is an estimate of the animals Na requirement.

The data collected in this trial fits this hypothesis in so far that the mean Na:K ratio initially increased with increasing Na intake, plateauing when Na intakes reach about 12 g/d.

Secondly, the total Na requirement can be calculated factorially by making allowance for the Na required for maintenance, and for losses in milk, urine, etc. The Agricultural Research Council (1980), in estimating Na requirements by this method, have derived the formula:

$$\text{Na requirement} = (\text{LW} \times 0.0064) + (\text{MW} \times 0.64) \text{ g/d}$$

where LW is live weight and MW is daily milk yield (kg).

Fig. 3 shows the mean Na:K ratio plotted against the Na intake which is expressed as the ratio of the Na intake to the Na requirement calculated using the ARC formula. The Na intake includes an allowance for the Na content of the basal diet.

While clearly this data cannot be described simply in terms of 2 straight lines the Na:K ratio has increased with Na intake to plateau at about 25:1 — a level similar to that reported by other authors for Na replete cattle (Bott *et al.*, 1964; Murphy and Plasto, 1972; Murphy and Gartner, 1974; Hennessy and Sundstrom, 1975). However examining that data in

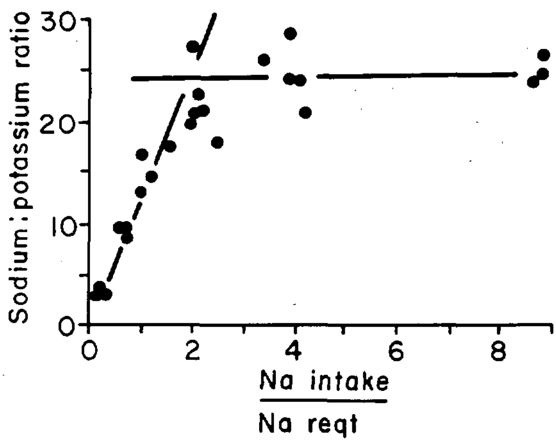

FIG. 3 Relationship between the mean Na:K ratio of parotid saliva and Na intake. Na intakes are expressed as a ratio of the Na intake to the estimated Na requirement (ARC, 1980).

this way shows the maximum Na:K ratio is not reached until daily Na intakes are about twice those currently recommended by the ARC (1980) for dairy cattle of the live weight and milk yield recorded in this trial.

The significance of the discrepancy in the 2 estimates of the Na requirement is unknown but may reflect differences in the criteria chosen to define an adequate Na intake. Only further work will show which of the 2 estimates is closer to the Na intake below which animal performance and production is adversely affected.

In summary the Na:K ratio of parotid saliva samples is dependent on the Na intake, changing rapidly to reflect changes in Na intake, important features of a diagnostic test for Na status. However before this measure can be used in the field to determine the need for Na supplementation a predictive relationship between this ratio and the likelihood of Na-dependent production responses must be established.

REFERENCES

ARC 1980. Agricultural Research Council. Requirements for the major mineral elements: Sodium and chlorine. *In*: The Nutrient Requirements of Ruminant Livestock, Commonwealth Agricultural Bureaux, Slough, pp. 213-216.

Bott Elspeth; Denton D. A.; Goding J. R. 1964. Sodium deficiency and corticosteroid secretion in cattle. *Nature* **202**: 461-463.

Davison T. M.; Murphy G. M.; Maroske M. M.; Arnold G. 1980. Milk yield response following sodium chloride supplementation of cows grazing a tropical grass-legume pasture. *Australian journal experimental agriculture and animal husbandry* **20**: 543-546.

Denton D. A. 1956. The effect of Na^+ depletion on the Na^+:K^+ ratio of the parotid saliva of the sheep. *Journal of physiology* **131**: 516-525.

Dobson A.; Kay R. N. B.; McDonald I. 1960. The relationship between the composition of parotid saliva and mixed saliva in sheep during the induction of sodium deficiency. *Research in veterinary science*: 103-110.

Hennessy D. W.; Sundstrom B. 1975. Na:K ratio in saliva of beef cattle grazing Kikuyu dominant pastures. *Journal of the Australian Institute of Agricultural Science* **41**: 59-60.

Kemp A.; Korzeniowski A.; Geurink J. H. 1972. Method for estimating the sodium status of cows. *Zeitschnift fur Tierphysiolie, Tierernahrung und Futtermittelkunde* **29**: 257-263.

Leche T. F. 1977. Effects of a sodium supplement on lactating cows and their calves on tropical pastures. *Papua New Guinea agricultural journal* **28**: 1-18.

Smith G. S.; Middleton K. R. 1978. Sodium and potassium content of topdressed pastures in New Zealand in relation to plant and animal nutrition. *New Zealand journal of experimental agriculture* **6**: 217-225.

Morris J. G.; Peterson R. G. 1975. Sodium requirements of lactating ewes. *Journal of nutrition* **105**: 595-598.

Murphy G. M.; Gartner R. J. W. 1974. Sodium levels in the saliva and faeces of cattle on normal and sodium deficient diets. *Australian veterinary journal* **50**: 280-281.

Murphy G. M.; Plasto A. W. 1972. Sodium deficiency in a beef cattle herd. *Australian veterinary journal* **48**: 129.

Skydsgaard J. M. 1967. En metode til diagnosticering af latent natriummangel i kvaegbesaetninger. *Nordick Veterinarmedicin* **19**: 346-349.