Effect of High Intakes of Sodium Chloride on the Utilization of a Protein Concentrate by Sheep. I Wool Growth

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Abstract

Both the water intakes and wool growth rates of sheep fed on a high protein diet (37% crude protein), consisting mainly of linseed meal, were significantly increased when salt (c. 130 g sodium chloride per day) was given in both the food and drinking water. Offering the food once a day resulted in a higher wool growth response to salt (22%) as compared with offering the food at 3-hr intervals (14%). It is suggested that the effects of salt were due to reduced ruminal degradation of protein, which remained in the rumen for a shorter time than usual when salt was given.

Introduction

In ruminants, dietary protein is subject to proteolysis and deamination in the rumen. This protein degradation may exceed protein synthesis by rumen microorganisms when the protein content of the diet is high, thus reducing the quantity of amino acids available for absorption from the small intestine (Hogan and Weston 1967; McDonald 1968). This apparent loss of protein can have a significant effect on wool growth because the rate of wool growth in sheep is considerably influenced by the quantity of amino acids absorbed from the small intestine (Reis and Schinckel 1961; Reis 1969). Various methods have been used to reduce the degradation of protein by rumen microorganisms. These include heat treatment of protein to reduce its solubility (Chalmers et al. 1954; Tagari et al. 1962; Danke et al. 1966), chemical modification with formaldehyde, other aldehydes and various tanning agents (Ferguson et al. 1967; Peter et al. 1970; Zelter et al. 1970; Barry 1972; Hemsley et al. 1973) and inhibition of rumen microbial activity with antibiotics (Hogan and Weston 1969). A further possibility is to shorten the time that food remains in the rumen, thus reducing the extent of protein degradation in the rumen, increasing amino acid absorption from the small intestine and, eventually, increasing wool growth.

In the present experiments a high protein basal diet was fed to sheep. The effects of adding sodium chloride to both the food and water and of feeding frequency on water intake, on the dilution of soluble rumen marker and on wool growth were examined. The results have received some corroboration from the work of Potter et al. (1972) who found that provision of saline drinking water to sheep increased the dilution rate of soluble rumen marker in the rumen.
Experimental

Diet

The basal diet, made up of 89% linseed meal, 9% ground wheaten straw, 1% ground limestone and 1% sodium chloride, contained 37% crude protein in the dry matter. The diet was offered as a loose mixture with or without additional sodium chloride.

Outline of Experiments

Five Merino wethers (c. 40 kg liveweight), housed indoors in individual pens, were offered 600 g of the basal diet daily.

Experiment 1 was in three phases. During a pre-experimental period of 6 weeks each sheep was offered the basal ration once daily at c. 0900 hours with tap water to drink ad libitum. During the first 8 days of the 8-week experimental period the salt treatment was gradually introduced until the animals were receiving 80 g sodium chloride in the daily ration, and the drinking water was replaced with 1% sodium chloride solution. During the post-experimental period of 8 weeks, conditions returned to those of the pre-experimental period.

In experiment 2 the basal ration of 600 g per day was offered in equal portions every 3 hr during the pre-experimental (9 weeks), experimental (6 weeks) and post-experimental (6 weeks) periods. During the experimental period 80 g sodium chloride per day was added to the basal ration, but the sodium chloride content of the drinking water offered to some sheep was reduced to minimize food refusals, which were recorded daily.

In both experiments 1 and 2 water intake was measured for 8–10 days towards the end of each period. The rate of wool growth was measured by clipping the wool grown on tattooed areas on the midside of each sheep during the final 2 weeks of each phase (Hemsley et al. 1973). Average wool fibre diameter was determined by Downes's (1971) method.

In experiment 3, another group of four sheep fitted with rumen cannulas was given the same dietary treatments as in experiments 1 and 2, and each sheep received all four treatments, viz. 24-hourly or 3-hourly feeding, with or without salt. After a preliminary period (c. 2 weeks) of adaptation to each treatment, a single dose (c. 200 μCi) of a soluble radioactive marker, the $^{51}$Cr complex of ethylenediaminetetra-acetic acid ($^{51}$Cr-EDTA) (Downes and McDonald 1964) was given in 200 ml water to each sheep through the rumen cannula, and the decline in $^{51}$Cr-EDTA concentration in the rumen was observed during the following 24 hr. Sheep fed once daily were given a dose of $^{51}$Cr-EDTA 4 hr before feeding and a second dose of $^{51}$Cr-EDTA 4 hr after fresh food was offered so that rumen volumes could be calculated both before and after feeding (Warner and Stacy 1968).

Results

Despite some food refusals, the salt treatment significantly increased water intakes and wool growth rates in both experiments 1 and 2. Wool fibre diameter was only significantly increased by salt in experiment 1 when feed was offered once a day (Table 1). The intake of sodium chloride was less during experiment 2 (3-hourly feeding) than during experiment 1. Both water intakes and wool growth rates were similar during the pre- and post-experimental periods, which indicated
negligible carry-over or seasonal effects. Although the sheep fed once a day showed a greater wool growth response to the salt treatment compared with the sheep fed every 3 hr, the interaction between feeding frequency and salt treatment on wool
growth was not significant at the 5% level. In experiment 1 (once-daily feeding) the salt treatment increased the time taken to consume the ration, but the sheep drank 75–80% of their daily water intake within 8 hr of being offered feed.

Table 1. Effect of sodium chloride and feeding frequency on water intake and on wool production by sheep offered a diet of linseed meal and straw

<table>
<thead>
<tr>
<th></th>
<th>Experiment 1 (one feed daily)</th>
<th>Experiment 2 (eight feeds daily)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Salt</td>
</tr>
<tr>
<td>Intake (g/day):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal diet</td>
<td>600</td>
<td>561</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>—</td>
<td>136</td>
</tr>
<tr>
<td>Water</td>
<td>1900</td>
<td>6100</td>
</tr>
<tr>
<td>Clean wool:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production (g/day)</td>
<td>7.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Fibre diameter (μm)</td>
<td>21.2</td>
<td>22.1</td>
</tr>
</tbody>
</table>

* Treatments differ significantly (P < 0.05).
A Control values are means for pre-experimental and post-experimental periods.

The rate of disappearance of $^{51}$Cr-EDTA from the rumen is shown in Fig. 1 for one sheep only under each of the four treatment conditions used in experiment 3, and average effects of salt and feeding frequency on rumen volumes and on

Fig. 1. Effect of salt intake and frequency of feeding on rumen marker (c. 200 μCi $^{51}$Cr-EDTA) dilution in sheep fed on a diet of linseed meal and straw. Comparisons are made between control (○) and salt treatment (●) diets offered (†) at 3-hourly intervals (a) or at 24-hourly intervals (b).

The rate of disappearance of $^{51}$Cr-EDTA from the rumen is shown in Fig. 1 for one sheep only under each of the four treatment conditions used in experiment 3, and average effects of salt and feeding frequency on rumen volumes and on
$^{51}$Cr-EDTA disappearance from the rumen are shown in Table 2. Although frequency of feeding had only a minor influence on the mean residence time, within each day the dilution rate of $^{51}$Cr-EDTA immediately after feeding was much greater when the sheep were fed once a day than when the sheep were fed every 3 hr. Rumen volumes of sheep fed once daily were lower before feeding than 4 hr after feeding, by which time most of the daily food and water had been consumed. The increase in rumen volume following feeding was more marked with the salt treatment; in some cases rumen volume was doubled. The proportion of $^{51}$Cr-EDTA passing from the rumen in the 4 hr after fresh food was greater with the salt treatment than with the control.

Table 2. Effect of sodium chloride and feeding frequency on rumen volume and disappearance of $^{51}$Cr-EDTA from the rumen of sheep offered a diet of linseed meal and straw (experiment 3)

<table>
<thead>
<tr>
<th>Values are means of four sheep</th>
<th>One feed daily</th>
<th>Eight feeds daily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Salt</td>
</tr>
<tr>
<td>Pre-feeding rumen volume$^a$ (litres)</td>
<td>5.8</td>
<td>6.1</td>
</tr>
<tr>
<td>Mean residence time of $^{51}$Cr-EDTA (hr)</td>
<td>5.1</td>
<td>18</td>
</tr>
<tr>
<td>Post-feeding rumen volume$^a$ (litres)</td>
<td>7.2</td>
<td>10.8</td>
</tr>
<tr>
<td>Rumen volume expansion (litres)</td>
<td>1.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Water intake during 4 hr feeding period (litres)</td>
<td>2.0</td>
<td>5.3</td>
</tr>
<tr>
<td>$^{51}$Cr-EDTA lost from rumen during 4 hr feeding period (%)</td>
<td>19</td>
<td>40</td>
</tr>
</tbody>
</table>

$^*$ Treatments differ significantly ($P < 0.05$).

$^a$ In sheep fed once daily, rumen volumes were estimated 4 hr before (pre-feeding) and 4 hr after (post-feeding) fresh food and water was offered.

Discussion

Both water intake and wool production by sheep fed on a high protein diet were significantly increased with high salt intakes. These responses occurred despite significant food refusals by some sheep when salt was given. The wool growth responses to high salt intakes found in the present experiments may occur only when the diet contains a high proportion of protein which is normally degraded in the rumen. The faster passage of water and soluble constituents through the rumen, caused by the high salt and water intake, suggests that more dietary protein could have escaped degradation in the rumen and thus enhanced the quantity of protein digested in the small intestines. Salt has been used in previous studies as a means of restricting the intake of supplements offered ad libitum (Weir and Miller 1953; Weir and Torell 1953; Peirce 1957) and no significant effect of salt on wool growth was found. However, in these experiments the diets offered were usually low protein roughages with or without small amounts of protein concentrates. Under these circumstances it might be expected that net protein degradation in the rumen would be small and consequently the effect of salt on protein digestion in the small intestine would also be small.

In subsequent experiments (Hemsley et al. 1975) it was found that under conditions similar to those of experiment 2 (3-hourly feeding) c. 49% of the
protein from linseed meal was apparently degraded in the rumen; this was reduced to 44% by the salt treatment. It is possible that protein degradation in the rumen was reduced further by the salt treatment in experiment 1 owing to an enhanced effect of the salt treatment soon after feeding on the passage of food from the rumen. In experiment 3 the rate of disappearance of $^{51}\text{Cr-EDTA}$ from the rumen in sheep fed once a day was greatest immediately after feeding, i.e. the period in which most of the daily food and water intake was consumed. The substantial dilution of marker after feeding and drinking was associated with an increased rumen volume and probably an increased outflow of digesta from the rumen, enabling more of the readily degradable protein to escape from the rumen at a time when the rate of protein degradation was maximal. The greater fibre diameter and wool growth response to salt under once-daily feeding conditions (experiment 1) supports the conclusion that the effect of salt in reducing ruminal protein degradation was greater when the interval between successive feeds was increased. There is also evidence that the utilization of dietary protein by sheep may be improved by a reduction in feeding frequency. Graham (1967) showed that nitrogen retention was not impaired by feeding every 4 days compared with more frequent feeding despite a lowered energy retention. Briggs (1968), Hill et al. (1968) and Langlands (1973) showed that wool growth was increased by feeding less frequently than once a day.

If the suggested mechanism of the wool growth response to salt is correct, then sheep which are most tolerant of salt and/or which consume the greatest quantity of water would also show the greatest wool growth response. Breeds of sheep vary in their tolerance of salt (Wilson and Hindley 1968) but no evidence is available concerning the relationship between salt tolerance and the wool production of individual sheep.

The sheep’s high tolerance of salt does not itself depress wool production, and our experiments have shown that salt may increase wool growth in certain circumstances. Depressed food intake caused by salty food or drinking water may depress wool production, but if energy requirements are being met the efficiency of wool production (e.g. wool per unit protein intake) from high protein diets or supplements susceptible to ruminal degradation will probably be improved by the action of salt in reducing the residence time of protein in the rumen.

Acknowledgments

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References


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