LACTIC ACIDOSIS IN THE CAECUM AND RUMEN OF SHEEP

by

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree.

I certify that, to the best of my knowledge, any help received in preparing this thesis, and all sources used, have been acknowledged.

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Abstract

A series of experiments was undertaken to explored the general hypothesisin that the rate of production and accumulation of lactic acid is more important than the buffering capacity within the gut in the development of fermentative acidosis. A comparative study of the absorption of lactic acid, volatile fatty acids (VFAs), glucose and ammonia from caecal and rumen pouches was undertaken in anaesthetised sheep. Test solutions varying in pH, osmolarity, lactic acid concentration, and with fixed concentrations of VFAs, ammonia and glucose (100 mmol/L, 7 mmol/L and 4 mmol/L, respectively) were introduced into clean, surgically sealed pouches. Studies were undertaken in nine sheep, each with two pouches in the caecum and one in the rumen. Samples were taken at 10-minute intervals for 50 minutes to determine rates of absorption. On the other hand, the buffering capacities of caecal and rumen digesta of sheep fed oaten chaff and pasture and fasted were determined by titration with lactic, acetic and hydrochloric acids. On the basis of integrating the experimental data in this study and incorporating this with information already available in the literature, a computer modelling approach was developed using the program STELLA II to study acid production and absorption, and to predict pH during fermentation.

The experimental results showed that neither L-lactic acid nor D-lactic acid was absorbed from the caecal or rumen pouch and that there was a slight increase in both isomers of lactic acid (0.39%/min L- lactic acid and 0.24%/min D- lactic acid averaged for the caecum and the rumen). This increatment in lactic acid was presumably due to conversion of propionic acid and tissue metabolism during the experiment. The rate of increase per unit area in the caecum (0.06 μmol/cm^2.min) was much greater than that in the rumen (0.015 μmol/cm^2.min) based on the average of L- and D- lactic acid. The absorption rates of acetic, propionic and butyric acids from the caecum (0.49, 0.17 and 0.03 μmol/cm^2.min, respectively) and from the rumen (0.48, 0.16 and 0.08 μmol/cm^2.min, respectively) were very similar based on absorptive surface area of the pouches. A decrease in pH, osmotic pressure or the concentration of lactic acid resulted in

corresponding increases in the absorption of VFAs. The mean absorption rate of ammonia from caeca pouches (0.60 μgN/cm^2.min) was 2.5 times greater than that from rumen pouches (0.24 μgN/cm^2.min) ($P < 0.0001$). The mean absorption rate of ammonia for the caecal and rumen pouches was about 2.6 times higher at pH 6.5 (0.99%/min) than that at pH 4.5 (0.38%/min) ($P < 0.0001$) at the same osmolarity and lactic acid concentration. Glucose was apparently absorbed from rumen pouches (0.18 μmol/cm^2.min), but not from caecal pouches (-0.01 μmol/cm^2.min).

Both rumen and caecal digesta had maximal buffering capacity between pH 6.0 and 6.5. The buffering capacity of caecal digesta was nearly double ($P < 0.001$) that of rumen digesta. The rumen digesta from sheep fed oaten chaff had a buffering capacity 21% higher ($P < 0.05$) than that of sheep grazing green pasture. This was reduced ($P < 0.05$) by one-third following ruminal infusions of glucose, lactic or acetic acid to induce acidosis. Oaten chaff and green pasture did not significantly affect the buffering capacities of rumen and caecal digesta. However, the buffering capacities of rumen and caecal digesta from pasture-fed sheep that had been fasted for 24 hours were significantly greater ($P < 0.001$) than those from sheep that had not been fasted (62 and 18%, respectively). The buffering capacity determined using HCl was always less than that for lactic or acetic acid. This may be due to the lower pKa for HCl and the fact that there is no evidence that HCl undergoes inter-conversion through fermentation that the organic acids may undergo. The addition of carbonate or phosphate buffer significantly increased ($P < 0.05$) the buffering capacities of rumen and caecal digesta. The sodium bicarbonate and sodium carbonate ($NaHCO_3$ and Na_2CO_3) system played a more effective buffering role than the sodium dihydrogen orthophosphate and disodium hydrogen orthophosphate (NaH_2PO_4 and Na_2HPO_4) system in the rumen digesta.

The computer model adequately predicted the experimental data and was relatively stable over the range of the values of the parameters tested. The model produced acceptable, responses in terms of lactic acid, VFAs and pH. The model provided a mathematical representation of fermentation processes in the rumen and was able to predict the accumulation of lactic acid and VFAs, and the pH under a number of "directory" conditions. The results are very useful for investigating effective methods and their mechanisms for the prevention and treatment

of lactic acidosis. It appears that the rate of fermentation and the amount of substrate are important factors in terms of the development of fermentative acidosis.

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