The University of New England
School of Rural Science

ASPECTS OF GLUCOSE SYNTHESIS IN SHEEP

by

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SECTION 5

SUMMARY

1. It was established that gluconeogenesis in sheep was affected by the quantity and quality of the diet.

With diets of similar digestible energy content but of varying proportions of maize to lucerne, the proportion of plasma glucose arising from propionate produced in the rumen was highest on the diet containing the greatest quantity of lucerne and decreased as the proportion of starch in the diet increased. The low volatile fatty acid concentrations and the reduced conversion of propionate to glucose on the high starch diets, despite similar propionate production rates and irreversible losses of plasma glucose, may have been due to starch escaping fermentation.

With different roughage diets, the irreversible loss of glucose increased linearly with the digestible energy and crude protein intake. As the correlation with protein intake was lower than that for energy intake and as the amount of protein which passes to the small intestine is to a large degree independent of the protein intake, it is suggested that protein intake is not causally related to the irreversible loss of plasma glucose. There was no apparent effect of diet on the proportion of plasma glucose derived from propionate or on the proportion of propionate produced in the rumen that was converted into

glucose. This indicates for the roughage diets used, that the relative contribution of glucogenic products of ruminal fermentation, particularly propionate and amino acids, to glucose synthesis is similar.

2. Short-term infusions of glucose and of certain products of ruminal fermentation were found to alter the gluconeogenic rate in fed sheep.

Intravenous infusions of glucose suppressed endogenous production of glucose in direct proportion to that infused for sheep given lucerne or wheat. The animals only partly adapted to the glucose infusion; the amount suppressed was equivalent to about one-quarter of the glucose infused. The glucose was apparently more effective in suppressing the synthesis of glucose from substrates other than ruminal propionate. The lower proportion of glucose carbon arising from blood bicarbonate on the high-starch diet may have been due to the absorption of glucose from the alimentary tract.

In sheep given lucerne, glucose synthesis rate was positively correlated with intraruminal infusions of propionate and with intra-abomasal infusions of amino acids. Approximately one-third of the infused substrate was apparently converted into glucose. Intramesenteric-vein infusions of propionate also

stimulated gluconeogenesis but infusions of butyrate produced only a transient increase in the glucose production rate. As glucose synthesis from propionate was not altered butyrate may have initiated glycogen mobilization.

3. In sheep given lucerne, estimates have been made for the total synthesis and resynthesis rate of glucose by using glucose labelled with tritium in positions 6, 3 or 2 with glucose labelled uniformly with carbon-14. Results show that recycling was less for tritium than carbon-14, particularly for tritium on positions 2 and 3 of glucose. Resynthesis of glucose carbon from blood bicarbonate was negligible as was the recycling of tritium through body water, although about 90% of the carbon-bound hydrogen of plasma glucose was apparently derived from body water. The recovery of tritium in body water from positions 3 and 6 of plasma glucose together with the approximate estimates of the proportion of glucose oxidized indicates that about 20 to 30% of the intermediates of glucose metabolism are utilized in synthetic reactions. These results are consistent with the complete recovery of tritium in body water from position 2 of plasma glucose. It is suggested that monoexponential analysis of the initial portion of the disappearance curve of [2-^{3}H]glucose

from plasma provides an estimate of the total synthesis rate of plasma glucose and in combination with [U-^{14}C]glucose the extent of glucose resynthesis. Estimates obtained this way indicate that 20% of the glucose carbon is recycled.

STATEMENT

I certify that this thesis has not already been submitted in substance for any degree and is not being currently submitted for any other degree. I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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PUBLICATIONS

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The contribution of propionate to glucose synthesis in sheep given diets of different grain content.
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Studies of the control of gluconeogenesis in sheep: effect of propionate, casein and butyrate infusions.
Br. J. Nutr. (in press).

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Aust. J. Biol. Sci. (in press).

ABBREVIATIONS

The following abbreviations have been used in this thesis:

ADP	adenosine 5'-diphosphate
ATP	adenosine 5'-triphosphate
CoA	Coenzyme A
Cyclic AMP	cyclic adenosine 3',5'-monophosphate
E.M.H.	Embden-Meyerhof pathway
NAD	nicotinamide adenosine dinucleotide
NADH	reduced nicotinamide adenosine dinucleotide
NADP	nicotinamide adenosine dinucleotide phosphate
NADPH	reduced nicotinamide adenosine dinucleotide phosphate
P.P.P.	pentose phosphate pathway
Rumen	reticulo-rumen
SR	specific radioactivity
VFA	volatile fatty acids

GLOSSARY

A glossary of those terms most frequently used in this thesis is given below. It was based in part on the recommendations of G.L. Brownell, M. Berman and J.S. Robertson to the International Commission of Radiation Units on the use of notation and nomenclature for tracer kinetics, published in 1968 in the Journal of Applied Radiation and Isotopes, volume 19, page 249.

System: A set of compartments between which transfer of a certain defined substance occurs.

Compartment: A kinetic entity in which it can be assumed that the defined substance is of uniform concentration and that the rates of movement within the compartment are very rapid with respect to movement to or from the compartment.

Pool size: Mass of defined substance within a compartment.

Irreversible loss: The rate at which the defined substance (mass/unit time) leaves the sampled compartment never to return to that compartment.

Total entry rate: The rate of entry (mass/unit time) of all the defined substance into the sampled compartment.