Improving the Efficiency of Starch Digestion in Beef Cattle

by

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List of Publications

Studies presented in this thesis have been presented at various national conferences and published or submitted for publication in scientific journals.

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Channon, A.F. and Rowe, J.B. (2003) Manipulating gastrointestinal starch digestion to improve the efficiency of feed utilisation. *Australian Journal of Experimental Agriculture* 43 (in press).

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Channon, A. F. and Rowe, J. B. (2002). Lactic acid in the rumen reduces feed intake in cattle. *Animal Production in Australia* 24, 279.

Channon, A. F. (2002). Is the efficiency of starch digestion genetically based? In: *Proceedings of the ALFA industry field day, conference and AGM*, pp. 47-54. Australian Lot Feeders' Association, Tamworth, Australia.

Channon, A. F., Rowe, J. B. and Herd, R. M. (2002). Genetic variation in starch digestion in feedlot cattle influences residual feed intake. In: *CRC for Cattle and Beef Quality, Annual Postgraduate Conference*, p. 18. CRC for Cattle and Beef Quality, Adelaide, Australia.

Channon, A. F., Brown, W. and Rowe, J. B. (2001). The acid test - how can we measure hindgut acidosis? *Recent Advances in Animal Nutrition in Australia* 13: 35A.

Channon, A. F. and Rowe, J. B. (2001). Processing grain to improve or shift the site of starch digestion. *Recent Advances in Animal Nutrition in Australia* 13: 36A.

Channon, A. F. and Rowe, J. B. (2001). Grain challenged cattle initially ferment starch in the hindgut. In: *CRC for Cattle and Beef Quality, Annual Postgraduate Conference*, p. 4. CRC for Cattle and Beef Quality, Coffs Harbour, Australia.

Rowe, J. B., Bird, S. H. and Channon, A. F. (2002). New approaches to managing acidosis. In: *Proceedings of the ALFA conference: Making profit from feedlot research – results from the CRC for Cattle and Beef Quality*, pp. 27-29. Australian Lot Feeders' Association, Toowoomba, Australia.

Rowe, J. B. and Channon, A. F. (2000). How site of gastrointestinal digestion affects efficiency of feed utilisation. In: *Proceedings of the Feed Efficiency Workshop*, pp. 69-72. (eds. J. A. Archer, R. M. Herd and P. F. Arthur). CRC for Cattle and Beef Quality, Armidale, Australia.

Abstract

The efficiency of feedlot cattle production largely depends on the utilisation of starch. Current grain selection and processing practices can achieve whole tract starch digestibility levels of greater than 95% but gross inefficiencies in feed utilisation can still occur. The aim of this thesis was to examine opportunities for improving the efficiency of starch digestion in beef cattle.

Aspects of starch digestion in the gastrointestinal tract of cattle were reviewed and it was concluded that, although the efficiency of starch utilisation is influenced by whole tract starch digestion, the site of starch digestion and the amount of acid produced in the rumen and hindgut can also significantly influence the efficiency of feed conversion. The small intestine is the most desirable site of starch digestion but limitations to digestion in the small intestine often mean that some starch passes undigested to the caecum and colon where fermentative digestion results in energy loss, acidification of gut contents and no benefit from microbial protein synthesis. Starch digestibility in the small intestine can be improved using grain selection and processing and the choices made should aim to minimise fermentative starch digestion in the rumen and hindgut, yet increase enzymatic starch digestion in the small intestine.

While the extent of genetic variation in starch digestion in cattle is unknown, between-animal differences in the capacity to digest starch may provide an important opportunity to improve the efficiency of starch utilisation and reduce the incidence of acidosis in feedlot cattle.

The experiments reported in this thesis were initiated to determine:

a) the scope for maximising pre-caecal starch digestion through grain selection and grain processing; and

b) the importance of hindgut fermentation/acidosis in cattle as a factor determining between-animal variation in the efficiency of feed utilisation.

In vitro and *in sacco* studies were used to examine differences between dry rolled and steam flaked grains. The results suggested that surface area is the major factor influencing the rate of microbial fermentation in the rumen whereas 'cooking' and its effect on cellular and chemical structures has more influence on starch digestibility in the small intestine. Importantly, these studies indicated that moderately steam flaked wheat and barley may ferment less in the rumen

than dry rolled wheat and barley, yet have a higher level of digestibility in the small intestine of cattle.

An experiment using cattle with rumen and caecal cannulas provided evidence that poorly flaked wheat fermented less in the rumen than dry rolled wheat but that there were no differences between these grains in the pattern of hindgut fermentation. This result suggested that starch from poorly flaked wheat was efficiently digested in the small intestine.

A carbohydrate overload model was developed where ground wheat was administered into the rumen of cattle at a rate of 20 g/kg liveweight (LW) on two occasions, separated by 24 h. The study revealed that, with this model, cattle unadapted to high-grain diets may be susceptible to the problem of hindgut acidosis even when fermentation conditions in the rumen are relatively normal. There was also significant between-animal variation in the extent of acidosis in the hindgut and rumen.

In a feedlot trial, groups of steers of known genetic background were shown to vary in faecal pH and dry matter (DM) content. Furthermore, cattle with more efficient feed conversion tended to have a higher faecal DM content. The finding suggests that there may be genetic variation between cattle in the level of hindgut fermentation on grain-based diets.

The findings reported in this thesis indicate that there are three ways in which starch utilisation by feedlot cattle can potentially be improved. Firstly, there are differences between grains and selection of grains characterised by a slow rate of starch digestion in the rumen and efficient small intestinal starch digestion is important. Secondly, appropriate processing should be applied to the grains: maintaining large particle size for slower rumen digestion and using heat treatment ('cooking') to increase digestion in the small intestine. Thirdly, it is possible to capitalise on genetic differences between cattle in their ability to efficiently digest starch and avoid problems associated with acid accumulation in the rumen and hindgut.

Table of Contents

List of Tables

List of Figures

List of Plates