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**Nutritional and Physiological
Effects of
Short-term Feeding
of an Early Maillard Browning
Casein to Growing Pigs**

A thesis presented in partial fulfilment of the
requirements for the degree of Masterate in Biochemistry
at Massey University.

MARK PHILIP JOHN GALL.

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ABSTRACT

In the present study the digestion of an early Maillard browned casein and the absorption and excretion of the digestion products, were evaluated in the growing pig. Additionally, the physiological responses to short-term ingestion were determined.

In an animal study male pigs were fed a lysine and glucose supplemented early Maillard browned casein at high levels (30 %) in a well balanced diet, for a period of 26 days. Further, a similar early Maillard browned casein was radioactively labelled with U¹⁴C-glucose and fed to pigs to differentiate Maillard compounds *in-vivo* into early Maillard products (Fructosyl-lysine) and advanced Maillard products (residual radioactivity not attributed to fructosyl-lysine). Total urine and faeces were collected and on slaughter a variety of physiological samples removed.

The apparent ileal and faecal digestibility of nitrogen, amino acids and Maillard products (total radioactivity, ϵ -DF-L and residual radioactivity) were determined. Additionally, ileal digesta was chromatographed by Sephadex G-15 gel filtration. Heat treatment caused a significant ($P < 0.05$) decrease in the digestion of nitrogen, and several non-essential and essential amino acids at the terminal ileum. Acid hydrolysed lysine (AHL) and arginine decreased the most. Regenerated lysine (RL) from the acid hydrolysis of ϵ -DF-L, greatly influenced the acid hydrolysed lysine content in ileal digesta and the diet. Regenerated lysine and, therefore, the apparent ileal digestibility of actual lysine ($AL = AHL - RL$) was found to vary considerably depending on whether ϵ -DF-L was present as a free molecule or protein bound. However, calculation of ileal lysine availability by acid hydrolysis was a predictive measurement of the actual lysine availability. The significant decreases in apparent amino acid ileal digestibility was accounted for by the presence of small limit peptides, 2 - 3 residues in length (430 MW). These appeared to be associated with Maillard compounds, particularly ϵ -DF-L. The FDNB reactive lysine content in ileal digesta showed that the majority of actual lysine was present as N-terminally peptide bound. Microorganisms in the large intestine significantly ($P < 0.05$) digested amino acids from the terminal ileum to the extent where differences due to heat treatment in the faeces were not apparent. The largest differences between apparent ileal and faecal digestibility coefficients showed a high correlation (0.99) with the least apparent ileal digestibility coefficients - particularly for the digestion of Maillard products. Maillard

products were detected in the small intestinal mucosa and both portal and jugular serum. The excretion of Maillard products was similar to other reported studies. However, large proportions of Maillard products, apparently absorbed by the terminal ileum, remained unaccounted for. A tabulation of the dietary intake levels of Maillard products, their digestion, absorption and excretion are reported. There was no major change in the urinary excretion of amino acids from the heated diet. Sephadex G-15 chromatography of urine showed that the Maillard products, mainly ϵ -DF-L, eluted in a molecular weight region (715 MW) higher than that present in ileal digesta. The former had a low association with amino acids.

Physiological responses were determined over a short-term (26 day) period to determine the effect of the ingested Maillard products on protein digestive functioning and liver and kidney responses to their metabolic transit. There were no major physiological changes related to protein digestive functioning in pigs. The enzymatic activities of pepsin, chymotrypsin and trypsin remained the same in digesta and tissues. There appeared ($P < 0.1$) to be an increase in the aminopeptidase N activity and protein content at the terminal ileum. The relative organ weights of the stomach, small intestine, caecum and large intestine remained the same. However, significantly ($P < 0.05$) lighter pancreas and greater proportions of small intestinal mucosa were shown. Furthermore, there was a significant ($P < 0.05$) decrease in the stomach contents and increase in the small intestine contents. There were also no major physiological changes to the liver and kidney functioning in pigs, with jugular serum enzymatic activities (alanine transaminase, aspartate transaminase and γ -glutamyl transpeptidase) and the levels of blood urea nitrogen (BUN) and creatinine, and the BUN/creatinine ratio remaining unchanged. Furthermore, urine volumes, specific gravity, osmolality, the excretion of urea nitrogen (N) and creatinine, and the urea N/creatinine ratio remained the same. Some concern was raised over the colour of the urine being reddy-brown from pigs fed the heated diet, but clinical analysis tests (iron, bilirubin, urobilinogen, hexosamines, porphyrins, indicans and homogentisic acid) were negative and did not identify the nature of these pigments. They do not appear to be from a dietary origin.

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