

PIG NUTRITION: THE NORTHERN HEMISPHERE SCENE

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Summary

The different production systems used in Northern America and parts of Canada compared to Australia means that most of the nutritional guidelines used in those areas have little or no application to Australia. However, recent developments in digestive physiology and in assessing amino acid requirements have direct relevance. These include **particulary** the concept of "real" digestibility and the use of the indirect amino acid oxidation technique for assessing amino acid metabolism.

I. INTRODUCTION

The nutritional scene in Northern America and parts of Canada is one of contrast. On one hand, the level of scientific research undertaken is very impressive. On the other hand, in the production of pigs in the **corn-soyabean** belt, where energy and amino acids are in abundance, and there is little or no emphasis on carcass quality, little nutritional information is needed in the formulation of diets for maximum growth.

As the latter production system has little application to the Australian scene, I will concentrate on the **former**- developments in nutritional research. There are two areas in particular that are interesting. The first is recent developments in digestive physiology in Canada, the United States and in Europe. The second is developments in the use of radioisotopes which offers the potential for rapidly assessing amino acid requirements and other aspects of amino acid metabolism.

II. CURRENT CONCEPTS IN DIGESTIVE PHYSIOLOGY

There is considerable interest in the concept of 'real' digestibility of amino acids. **This** concept has developed from studies with 15-N in rats (Low 1982). Apparent digestibility (ileal or faecal) makes no allowance for endogenous losses. True digestibility attempts to correct for endogenous losses, using estimates based on nitrogen free diets or regression analysis. "Real" digestibility is the digestibility of an amino acid as determined using 15-N studies. These studies indicate that "real" digestibility may be much higher than that indicated by true digestibility values and may be in the order of **96-97%** for some proteins.

If this was found to be applicable for a wide range of protein sources then it indicates there is a need for information for the two components of digestion - the 'real' digestibility of amino acids and the endogenous cost of achieving this digestion. The former would probably be in the high **90%** for cereals, whereas the latter would be in the order of **10-25%**, depending on fibre content etc.

In the formulation of least cost diets involving cereals, apparent ileal digestibility values would seem more meaningful than true or "real" digestibility, as allowance has to be made for the endogenous cost of digestion, when determining the economic value of potential feed ingredients. However, in the computer simulation of pig growth, knowledge of both the "real" digestibility of amino acids, and the amount of endogenous amino acids

used to achieve that digestibility, would seem necessary if accurate prediction of the response is to be achieved.

An alternative to using 15-N for assessing "real" digestibility of lysine was developed by **Hagemester** and co-workers in West Germany. Lysine was transformed to homoarginine, and the homoarginine content of the **digesta** monitored. As homoarginine is not used in protein synthesis, it does not appear in the endogenous protein and thus the "real" digestibility of lysine can be estimated. Their studies also indicate very high digestibility of lysine in foods for miniature pigs, of the order of **98-99%**.

Another interesting finding is that of Sauer and Ozimek (University of Alberta), who concluded in a review of the literature that at least 30% of the protein at the terminal ileum may be of microbial origin. This suggests that there may be greater microbial activity in the small **intestines** than is normally thought. If this is so, then it complicates the estimation of digestibility of amino acids and the quantity of endogenous amino acids associated with digestion.

In an attempt to develop a suitable technique for the routine estimation of ileal digestibility of feeds, **Darcy-Vrillon** and **Laplace** (1985) have examined an **ileo-rectal** anastomosis procedure. With this technique, the terminal ileum is joined to the rectum, thus bypassing the large intestines. Appropriate adjustments have to be made to the diet to ensure an adequate supply of minerals and to prevent dehydration. If suitable, the technique offers the potential for the routine estimation of ileal digestibility. It would also have application if it was used in conjunction with the mobile nylon bag technique (Sauer et al, 1983). The latter technique currently suffers the disadvantage that it is more suited for estimating faecal digestibility, as it is difficult to recover the nylon bags as they pass the terminal ileum.

III. USE OF RADIOISOTOPES IN DETERMINING AMINO ACID **REQUIREMENTS**

An indicator amino acid oxidation technique for assessing **amnio** acid requirements has **beed** developed by Professor **H. S. Bayley** and colleagues at the University of Guelph (Kim et al. 1983). This technique is based on the following **principles**:- When a surplus amino acid is broken down, the nitrogen portion is excreted in the urine and the remainder used for energy. In the oxidation of the amino acid some of the carbon molecule is released as carbon dioxide. Thus by labelling an amino acid with its 14-C isotope and measuring the amount of radioactive carbon dioxide released it is possible to monitor amino acid metabolism and to determine amino acid requirements.

Equipment utilized includes a chamber in which the pig or piglet is placed. Air is drawn through the chamber by means of pumps and the respired carbon dioxide in the air collected with chemicals in gas washing bottles. Prior to being placed in the chambers the pigs are fed the **labelled** amino acid and the amount of radioactivity in the respired air is then measured with a scintillation counter.

The technique is applied to determining amino acid requirements in the following manner:- When an amino acid is limiting in a diet, the addition of a graded amount of that amino acid will result in an increase in protein synthesis and there will be no change in the basal amount of that amino acid oxidised. However, once the requirement for that amino acid is met any additional increment will be surplus to needs and will be oxidised. Thus by adding graded amounts of the **labelled** limiting amino acid and plotting the inflexion point (when the surplus amino acid is oxidised) it is possible to determine the requirement (see Figure 1).

One limitation, however, is that not all essential amino acids are

Fig. 1 - Direct oxidation technique

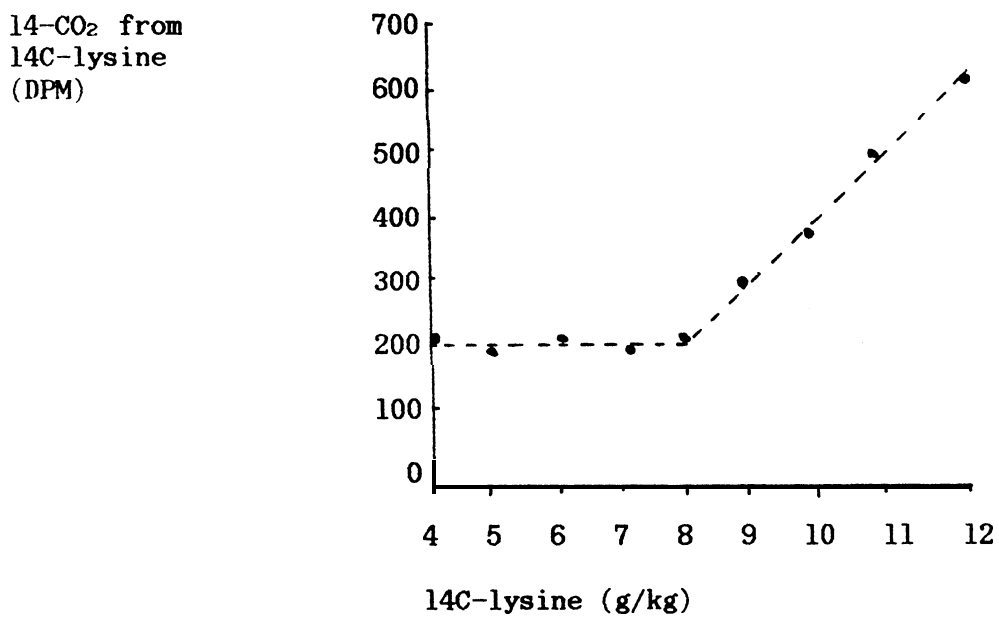


Fig. 2 - Indirect oxidation technique

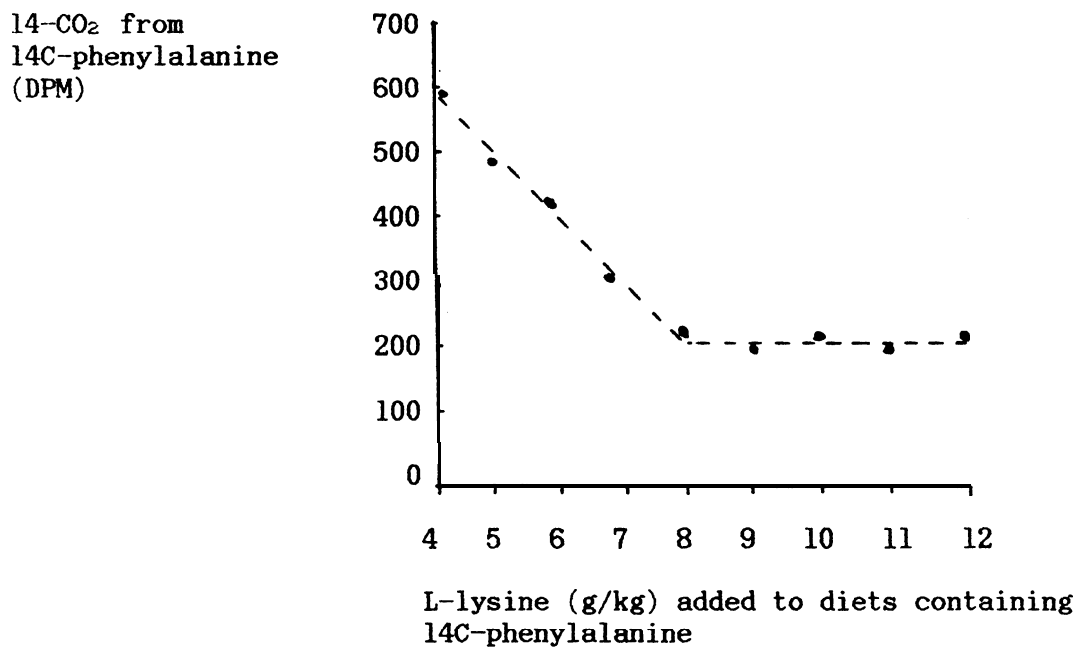


Fig. 1 and 2 - Radioactivity released as 14-CO₂ from pigs given 14-C lysine (Fig. 1) or 14C-phenylalanine (Fig. 2). In both cases the inflexion point indicates a requirement of 8 g/kg for L-lysine.

commercially available in the **carboxyl-labelled** L-isomer form and some that **are**, are very expensive. Accordingly, the indirect oxidation technique was developed and it allows measurement of the metabolism of all essential amino acids using a less expensive **labelled** amino acid.

With this technique, ¹⁴C phenylalanine has been used as the indicator amino acid. When one amino acid is limiting (say lysine) all the other surplus essential amino acids (including phenylalanine) are oxidised. When lysine is added to the deficient diet this will result in an increase in protein synthesis and a corresponding decrease in the amount of excess of the other essential amino acids. Thus there will be a decrease in the oxidation of phenylalanine and the other essential amino acids. However, once the requirement for lysine has been met any further addition of lysine will not increase protein synthesis nor affect the amount of phenylalanine (or other essential amino acids) oxidised. Thus by measuring the release of radioactive carbon dioxide from ¹⁴C phenylalanine added at a constant amount to diets containing graded levels of any essential amino acid it is possible to estimate the requirement for that amino acid (see Figure 2).

The advantages of the indicator amino acid oxidation technique is that it allows rapid estimation (three to five hours) of the essential amino acid requirements of pigs or piglets. The technique has been applied initially to baby pigs where it is not possible for health reasons to apply imbalanced diets for any length of time. It also offers the opportunity of repeated measurements (say weekly) of amino acid requirements with the one set of rapidly growing animals. The main limitations of the technique are the initial equipment required to use the isotopes and the cost of the ¹⁴C phenylalanine and associated chemicals.

During the last 12 months whilst I was working at the University of Guelph, I was able to apply the technique to three aspects of protein metabolism. In the first, it was used to measure protein metabolism as affected by the utilization of free and protein-bound amino acids fed once or six times daily. The initial studies were with ¹⁴C lysine but these were unsuccessful due to a differential dilution of the isotope in the diets containing free or protein-bound lysine. However, by using ¹⁴C phenylalanine as the indicator amino acid,, it was possible to show that there was a 25% greater oxidation of surplus amino acid from the diet containing free lysine with once daily feeding. With frequent feeding, there were no differences in the oxidation of phenylalanine from either diet indicating that the free lysine supplement was used with similar efficiency as the protein-bound lysine. These studies confirmed the earlier growth studies at Wollongbar, that supplements of free lysine are rapidly absorbed with once daily feeding and result in a temporal imbalance of amino acids at the sites of metabolism.

The second aspect was in determining amino acid requirements. With this, the lysine requirement of male 25 kg pigs was determined. Their estimated requirement of approximately **0.75-0.8%** was in agreement with current National Research Council (1979) recommendations. However, the estimate was considerably lower than that of similar weight pigs that have been selected for lean deposition in Australia.

With the third series of studies, attempts were made to develop an assay to assess amino acid availability. However, greater variability resulted in the measurements from pigs fed the experimental diets containing cottonseed meal and this prevented an accurate estimate of lysine availability. Further developmental work is required to minimise the source of variability.

Overall these studies indicated that the indicator amino acid oxidation technique could be a very useful tool in studying amino acid metabolism and

determining amino acid requirements.

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