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Protein and amino acids: from building blocks to food and health

WL Bryden

School of Animal Studies, University of Queensland, Gatton QLD 4343, AUSTRALIA

Nutrition is an integrative science that brings together many aspects of agriculture, biochemistry, physiology and medicine. In the latter half of the 20th century there has been significant advances in our understanding of the nutrition of all domestic animal species and man; often through comparative studies. This has been particularly true of farm animals, namely poultry, pigs and ruminants, both cattle and sheep. Space and time have necessarily restricted the following review to amino acid and protein nutrition: it seems appropriate to discuss protein at this meeting as this macro-nutrient has been largely forgotten in the fierce debates that have raged over fats and carbohydrates during the last 20 years.

Feed accounts for about 60% of the costs of animal production and this fact has justified the quest for efficiency in the use of feed resources. Protein and energy supply contribute 90% of feed costs and much research effort has been aimed at defining the requirements of animals for these nutrients and the corresponding nutrient attributes of feedstuffs. This has largely been achieved empirically in monogastric species but in ruminants, microbial fermentation in the rumen effectively transforms the nutrition of this species. The extensive fermentation of carbohydrate and protein in the rumen clearly established that the rational assessment of the nutritional needs of ruminants can only be made if the quantity of individual nutrients that are available to the animal post ruminally can be quantified. Isotope dilution techniques linked to arteriovenous difference measurements and blood flow data, have made important contributions to knowledge of cellular metabolism and quantitative nutrition of ruminants.

Protein and amino acid requirements of monogastrics have been defined for different physiological states and attempts to balance nutrient intake with nutrient requirements have centred around detailed studies of the nutritional attributes of feed ingredients. There has been considerable effort recently to develop systems that allow compilation of the available nutrients, especially available amino acids within feedstuffs. Digestibility values of amino acids in the ileum are used widely as an estimate of availability. Various techniques to quantify the endogenous loss of amino acids during digestion and absorption have been developed and evaluated in an attempt to quantify this important aspect of protein metabolism. Strategies to reduce endogenous losses have been developed. Peptide metabolism in, and uptake from the gut is a significant aspect of intestinal amino acid utilisation. Studies in ruminants have quantified amino acid flows to defined tissues, especially muscle and the mammary gland and the uptake and utilisation of these nutrients by these organs. In addition, studies within the rumen have clearly elucidated the interactions of microbes with dietary feed sources and the production of microbial protein. Delineation of the production, absorption and utilisation of volatile fatty acids has largely come from studies in ruminant animals.

The concept of a nutrient requirement which is pertinent only to a unique situation and is essentially a single point on a dose response curve is largely outdated. It is of far greater value to define the entire curve and thus have nutrient responses to different intakes and circumstances. The partitioning of amino acids between different tissues and organs, the effects of different physiological states, stress, disease and toxicological (mycotoxin) insults requires better definition in relation to the efficient use of dietary protein. Greater understanding will increase rates of protein deposition (growth and egg production) and secretion (lactation) in animal products and facilitate the development of functional foods of animal origin.

In parallel with the rapid progress of nutrition over the last 50 years, there have been great developments in the area of genetics and molecular biology. The advancement of nutritional science and its application to human and animal nutrition will rely increasingly on molecular technologies. The application of genomic technology to nutrition (nutrigenomics) will allow the identification of modified gene expression in response to nutrients to be established for thousands of mammalian genes. This will enable the development of a much stronger theoretical and molecular bases for nutrient responses. However, in the post-genomic era, functional genomics will need to be coupled with techniques that allow integration with whole-body metabolism will enable the prediction of phenotypic outputs of metabolic pathways and the implications of amino acid fluxes on metabolism and nutrition.

Molecular biology is likely to fuel major advances in our understanding of nutritional science. This knowledge and the development of efficient technologies for producing food conveys an optimism that a quality food supply will be sustained for an ever increasing human population in the 21st century.