Protein Feeding and Balancing for Amino Acids in Lactating Dairy Cattle

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KEYWORDS

• Amino acids • Lactation • Metabolizable protein • Microbial protein • Limiting AA

KEY POINTS

- Amino acid (AA) nutrition of the dairy cow is complicated because of feeding 2 systems at the same time: one microbial and one mammalian.
- The cow must detoxify ammonia to urea; excess urea is secreted in urine.
- Several nutrition models can predict duodenal flow of protein and essential AA (EAA) with reasonable accuracy as well as the digestible flow of individual EAA leading to a prediction of metabolizable protein (MP).
- Metabolism of absorbed AA still has not been well characterized.
- All EAA can become limiting depending on the diet, but lysine, methionine, histidine, and leucine have been the most studied.
- Requirements for MP and AA for the lactating dairy cow have also not been well defined.
- Balancing for MP and AA should allow feeding of lower protein rations resulting in greater milk nitrogen efficiency and less environmental impact.
- AA balance for dairy cattle is still an evolving science.

INTRODUCTION

Nature has made the protein nutrition of the lactating dairy cow complicated. When dairy cows are fed, two systems are being fed: a microbial system that can use amino acid (AA) but whose basic requirement is for ammonia and nonprotein nitrogen (NPN),

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and a mammalian system that requires AA and must detoxify ammonia as in other mammalian species.

Interdependency of these systems complicates defining AA requirements and supply. First, the amount of microbial protein (MCP) must be determined, and then this amount must be separated from dietary AAs that escape rumen degradation. The sum of MCP and dietary AAs that escape rumen degradation and that flows to the small intestine is, after digestion in the small intestine, termed metabolizable protein (MP). The term MP is used to define the total AA available to the cow in support of all physiologic functions.

Studies that are needed to close gaps in the knowledge of these interactions, in order that cow MP requirements may be better defined, require costly and invasive techniques. Furthermore, animal studies are often of short duration, because both of the expense and the intensive labor needed to conduct such studies. This limitation should be considered when evaluating AA effects because in the short term, the animal may be able to use body protein to fulfill deficiencies. The body condition loss in early lactation is a good example. Conversely, the animal may respond to AA treatment in the short term but may adjust and show no response in the longer term.[1]

On a practical basis, dietary crude protein (CP) is often overfed to ensure a sufficient supply of all AA to support all biological functions. Balancing milking cow rations for AA can increase profitability by lowering protein cost and increasing production of milk and milk protein.[2,3] However, this does not occur in all circumstances.[4,5] Lowering CP intake by adequate balancing for AA will reduce urea excretion and therefore environmental pollution. Unfortunately, lowering the MP supply without regard to the AA composition of the MP can significantly reduce milk production.[3,5]

For a variety of reasons, there are many questions regarding the application of AA balancing. There is a need for specific field recommendations regarding the use of MP and AA concepts to achieve greater economy and efficiency of protein utilization.

The purpose of this article is to describe the current knowledge of protein and AA metabolism in lactating cows with an emphasis on information generated since National Research Council (NRC) 2001, discuss areas where the knowledge is incomplete, and suggest some recommendations to make AA balancing practical.

Amino Acids for Dairy Cows

Of the 20 AAs required to build proteins, 9 are considered essential because the cow cannot produce them: histidine (His), isoleucine (Ile), leucine (Leu), lysine (Lys), methionine (Met), phenylalanine (Phe), threonine (Thr), tryptophan (Trp), and valine (Val). Although arginine (Arg) can be synthesized by the cow, it should be considered provisionally essential because it can become limiting under conditions of high production or disease.[6]

The nonessential AAs (NEAA) are also required for protein synthesis, but in addition to dietary sources, they are all synthesized by tissues from other AAs, both essential and nonessential.[7] In addition to dietary sources of protein that escape rumen degradation, rumen bacteria produce both NEAA and essential AA (EAA). The AAs of rumen microbes are well-digested and reasonably well-balanced relative to the AA needs of the cow, whereas both the digestibility and the balance of dietary AA can vary considerably.

AMINO ACID FLOW TO THE SMALL INTESTINE

The flow of AA arriving at the duodenum with the potential to be digested and absorbed originates from 3 sources:

- MCP leaving the rumen
- Undegraded portion of feed protein
- Endogenous protein secreted by gut tissue