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DAIRY RESEARCH RESULTS
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Rumen-Protected Amino Acids

1. Background

All animals require amino acids (AA), the building blocks of proteins required for optimal growth, reproduction, lactation, and maintenance. Amino acids absorbed in the cow's small intestine are derived from microbial protein and from dietary proteins that are *undegraded d*in the rumen. As explained in article **1P1**, proteins digested in the small intestine must supply 10 *essentia l* amino acids (EAA), which cannot be manufactured by the cow. And, ideally, the relative proportions of each of the EAA absorbed would exactly match the cow's requirements, because a shortage of one can limit the utilization of others.

To increase the total AA supply to the small intestine, it has become common practice to include supplemental undegradable intake protein (UIP or *bypas s* protein) to rations for lactating cows. However, production responses to supplemental UIP are not always positive. In a recent summary of 88 experiments where high UIP supplements replaced soybean meal, milk yield increased in only 17 and milk protein percentage increased in only five. Why were there so few positive responses?

In some instances, increasing the proportion of dietary UIP may create a shortage of *degradable* intake protein (DIP) required for microbial protein synthesis, resulting in no net change in total protein flow to the small intestine. In addition, although the EAA balance of microbial protein is similar to that required for growth and milk production, many high UIP feeds are low in one or more EAA (figure 1). When cereal based sources of UIP (com gluten meal, brewers' grains, distillers' grains) are used to supplement corn- or barley-based diets, lysine is commonly the first limiting AA. Methionine is likely to be first-limiting when legume- or animal-based proteins are the main sources of UIP.

Feeding combinations of UIP sources with complementary EAA profiles may improve overall EAA delivery to the small intestine. A more direct approach is to predict dietary EAA limitations and supplement these diets with specific rumen-protected amino acids (RPAA).

Amino Acid Supplementation

Free AA are of little value in ruminant diets because they are degraded rapidly in the rumen. Therefore, chemical alteration or physical protection are required to increase the supply of specific AA to the small intestine. In addition, a balance must be achieved so that AA protected from ruminal degradation are still available for intestinal absorption. Furthermore, these RPAA should be stable both when pelleted and when incorporated into silage-based TMRs where the pH can be as low as 3.6. Several approaches to AA modification have been tested:

- *Chemical AA derivatives* One of the more tested AA derivatives is methionine hydroxy analog (MHA®). Results have been variable with only occasional improvements in milk and milk fat production.
- *AA-mineral chelates* Trials in Pennsylvania suggested that zinc-methionine complexes were not degraded to any substantial extent in the rumen. At Washington State University, addition of zinc-methionine and zinc-lysine significantly increased milk production. The drawback to using zinc AA chelates is the high level of zinc added to the diet. At typical levels of AA supplementation, zinc levels may be 10-20 times above normal.

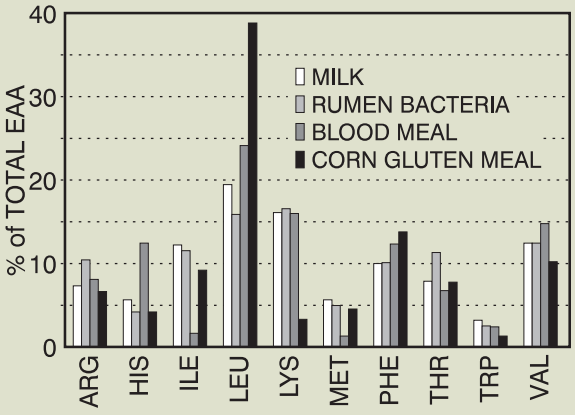

Figure 1 : A comparison of essential amino acid profiles. Notice the close match between milk and rumen bacteria and the disparity between these and the two common sources of UIP.

- *Fat encapsulation* .Fat has been used to protect RPAA but the total proportion of amino acid has usually been only about 30% by weight. South Dakota researchers conducted several studies with a fatty acid (58%) - methionine (30%) prill, demonstrating variable results in improving milk production. Others have concluded that encapsulation improved methionine status in the animal but that lysine often became the next limiting amino acid, negating production responses. Megalac-Plus® is a commercial formulation, currently available, which contains 13 g of methionine hydroxy analog with 450 g of Megalac® (calcium salts of long chain fatty acids).
- *pH-sensitive polymers* Polymers that are pH-sensitive have been used to encapsulate methionine and lysine. The polymer is stable at ruminal pH, but breaks down when it is exposed to abomasal pH, releasing the free AA for absorption in the small intestine. Examples of such products are Smartamine M® (70% methionine) and ML® (15% methionine, 50%lysine). Mepron M85® is another protected methionine product which is coated with compounds that are not pH-sensitive, but are resistant to ruminal, but not intestinal digestion.
- *High-lysine yeast* .Recently, Japanese workers reported their work on the isolation of a lysine-accumulating yeast that could accumulate from 4 to 15% of its dry weight as lysine. The majority of the lysine is contained in vacuoles that are stable when incubated with rumen fluid, but immediately released when exposed to pepsin, one of the protein-digesting enzymes of the abomasum. Thus, feeding this organism could increase the amount of lysine for intestinal absorption.

A recent review on feeding RPAA to lactating cows emphasized that optimizing intestinal AA balance is more important to improving milk protein level than is the ration crude protein level or the total quantity of protein absorbed. Feeding RPAA has consistently increased protein production and milk protein concentration which is important in cheese making. However, increases in milk production have been variable. For example, a collaborative study in which we were involved showed that feeding lysine and methionine in a ruminally inert coating increased milk production, milk fat, and milk protein production. In contrast, Wisconsin researchers fed early lactation cows a combination of protected methionine and lysine and reported an increase in milk protein but no increase in production.

Inconsistent production responses to RPAA may be due to the possibility that several EAA are often co-limiting. In addition, some AA have several metabolic roles other than as precursors for protein synthesis. For example, methionine is essential in fat synthesis and transport. And depending on the availability of other precursors, amino acids may make a significant contribution to glucose synthesis in the liver (see article **1L1**).

RPAA advantages

There are several potential advantages to using RPAA in lactation diets:

- A small amount of RPAA can replace a sizeable amount of UIP. In the collaborative trial mentioned above, we replaced 500 g of a soy/blood meal combination with 50 g of RPAA. Both groups had similar dry matter intakes and milk production. Cows supplemented with RPAA consumed less protein and more forage than protein supplemented cows. Having more room in the diet offers more flexibility in diet formulation.
- By-product feeds low in methionine and lysine could be more fully utilized knowing that RPAA could overcome AA limitations in these feeds.
- Use of RPAA could be used to supplement cows in the dry period without creating the potential for downer cow syndrome that may occur when feeding high levels of protein.
- Feeding supplemental fat to lactating dairy cows increases the energy density of the diet but often results in decreased milk protein. Feeding RPAA has been shown to overcome this problem.
- Nitrogen pollution of surface and groundwater and environmental acidification from livestock are increasing problems in many areas of the world. Utilizing RPAA technology is “environmentally friendly” in that it improves the efficiency of protein utilization.

Future articles in this series will describe our trials designed to exploit the advantages of RPAA.

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