# Setting Yourself Up for Success with Amino Acid Balancing

**Jessica Tekippe**[1]
*Ajinomoto Heartland Inc.*

## Introduction - Why Protein Nutrition is Important

Of the nitrogen fed to dairy cows, only 21 to 38 percent actually is exported as milk or meat. Consequently, 62 to 79 percent of the nitrogen fed is excreted in urine and feces. Can we increase the efficiency of nitrogen utilization? Yes, we can via amino acid balancing. What started as a catchy phrase has become a best practice when formulating dairy rations. Our counterparts in the swine and poultry industries, in monogastric livestock production, have long realized and capitalized on the production and efficiencies that occur when balancing for an animal's specific amino acid requirements.

In our defense, the ruminant animal is much more complex. With ruminants, amino acids need to be protected enough to get past the rumen, so they can be available for digestion and absorption in the small intestine. The "crude" protein we originally balanced for was actually a composite of different amino acids. As an industry, we want to move the dairy business forward. Amino acid balancing provides additional opportunities for the dairy to profit, i.e., higher milk and component production or reduced protein needs.

Ideally, each amino acid's supply and requirements would be identical matches. However, the amino acid composition of milk protein differs from the amino acid composition of feed ingredient protein. This mismatch often results in deficiencies of amino acids in dairy rations. These deficiencies, in turn, result in production or profit inefficiencies. When amino acids are supplied at levels below cow requirements, milk production is limited. Two amino acids are typically first limiting, methionine and lysine. It is absolutely necessary that these two amino acids make up a certain portion of the dietary protein content. Without them, dairy cows simply cannot produce at peak potential.

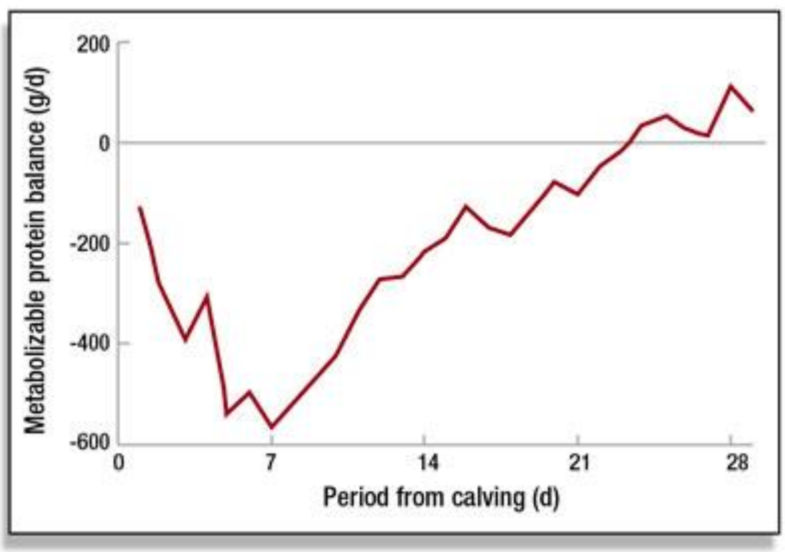
## Transition Potential

Transition management directly impacts milk production and the bottom line. Poor transition periods can result in the loss of 10 to 20 pounds of peak milk per cow per day. That's significant – because for every pound of potential milk unrealized at peak production, the herd's total milk production for the lactation decreases approximately 200 pounds. This could represent 2,000 to 4,000 pounds of potential milk lost per cow per lactation. Cow management at transition is critical. It is closely linked to not only lactation performance but also to clinical and subclinical postpartum diseases and reproductive performance. Why? Transition is a critical turning point. Cows move

[1] Contact: 8430 W. Bryn Mawr; Suite 650; Chicago, IL 60631 Email: tekippej@ajiusa.com

from non-lactating to lactating. There truly is a transition in the cow's physiology, metabolism, and nutritional requirements for three weeks prepartum until three weeks postpartum. During the critical transition period, several factors deserve management's focus. Prominent among these is the normal decrease in dry matter intake (**DMI**) as calving approaches. As DMI is compromised, a negative energy balance develops. DMI can decrease at a rate of approximately 2 percent of body weight during the first several weeks of the dry period. This ramps up to 1.4 percent of body weight during the seven days prior to calving. As cows approach transition, an overall 30 percent decrease in DMI may seem to have occurred rapidly.

After calving, cows enter negative energy balance. For example, the energy requirement of a cow producing 55 pounds of milk per day just two days after calving is about twice as high as her energy requirement two days before calving. The three weeks after calving, DMI is increasing at the rate of 3.3 pounds (1.5 kg) to 5.5 pounds (2.5 kg) per week, and negative energy balance corrects. How do we assist cows in maintaining energy balance? One strategy is to use concentrated nutrients that take up less room in the already limiting dry matter space and to balance amino acid levels. Balancing for amino acids is an increasingly common ration management tool that benefits all cows. Proteins are built from amino acids and have numerous and varied roles in cows. Today's rumen-protected amino acid products are concentrated nutrients that take comparatively little space in the ration. Their positive effects on transition cows are continuing to be revealed by research. At transition (Figure below), if rations contain insufficient levels of amino acids and proteins, cows mobilize their limited protein reserves. These reserves are located in peripheral tissues and muscle.




At transition, the synthesis of proteins and the efficiency of protein synthesis both increase, yet the diet should theoretically require a higher concentration of amino acids due to the reduced DMI. Rumen-protected amino acids can help ease this nutritional burden. During the last seven to 10 days of pregnancy, cows mobilize 1,000 grams of tissue every day. At the end of gestation, the uterus itself is extracting 72 percent of the amino acids in circulation. Methionine and lysine are the first two limiting amino acids. In lactating cows, either histidine or arginine appears to be the next limiting. In transition cows, however, arginine is considered the next limiting after lysine and methionine.

Insufficient supplies in the wrong quantities can limit herd production and performance. For example, methionine is important for immune function, milk protein synthesis, and the formation of cysteine, an amino acid necessary for milk protein synthesis and immune system antioxidants. When methionine is lacking, and cysteine becomes limiting, cows can start to suffer from stress, inflammation, and immunosuppression. A shortage of lysine would be expected to first affect production, then reproduction, and then the immune system. Eventually, it could affect all body functions and systems, as lysine is a building block of several proteins with widely varying purposes in the body. Excess amino acid supplies have consequences too, so precision is important. An oversupply of methionine, for instance, throws off the balance of the lysine-to-methionine ratio and can have profound effects by further reducing DMI. This is supported by the hepatic oxidation theory. This theory suggests cows will stop eating based on the signals carried from the liver to the brain. These signals can be triggered when an excess supply of methionine is present and is not being used due to the limited lysine supply. An approximately 3-to-1 ratio of lysine to methionine is strongly recommended for cows through the transition period. The exact ratio varies somewhat among the various commercial ration formulation software programs. The correspon-ding grams of lysine and methionine would be around 96 to 32 for prefresh and 180 to 60 after calving.

Several transition studies on amino acid nutrition have been presented at the annual meetings of the American Dairy Science Association in recent years. Let’s consider highlights: In one study (Table below), cows were fed zero, 16, and 32 grams of supplemental lysine for the four weeks following calving (Bell et al., 2000).

| | 0 - 4 weeks in lactation | | | 5 - 8 weeks in lactation | | |
|---|---|---|---|---|---|---|
| | Control | Lysine, 16 g | Lysine, 32 g | Control | Weeks 0-4, 16 g lysine; Weeks 5-8, control diet | Weeks 0-4, 32 g lysine; Weeks 5-8, control diet |
| Milk, lbs | 81.8[a] | 84.9[b] | 86.4[b] | 94.4 | 94.8 | 92.7 |

[a,b] Means are different, $P < 0.05$.

The resulting milk production was 81, 84 and 86 pounds, respectively. The milk volume response to lysine plateaued when the percent of lysine to metabolizable protein reached 7.67 and 8.36 – meaning the current recommendations might be too low. Further research is needed. Following the treatments, all groups were fed the control diet. Interestingly, milk production for the cows initially supplemented with amino acids and the control cows converged. This indicates that proper use of amino acid nutrition is vital as lactation progresses.

In another transition study, from three weeks before calving until three weeks post-calving, cows were assigned treatments as follows:

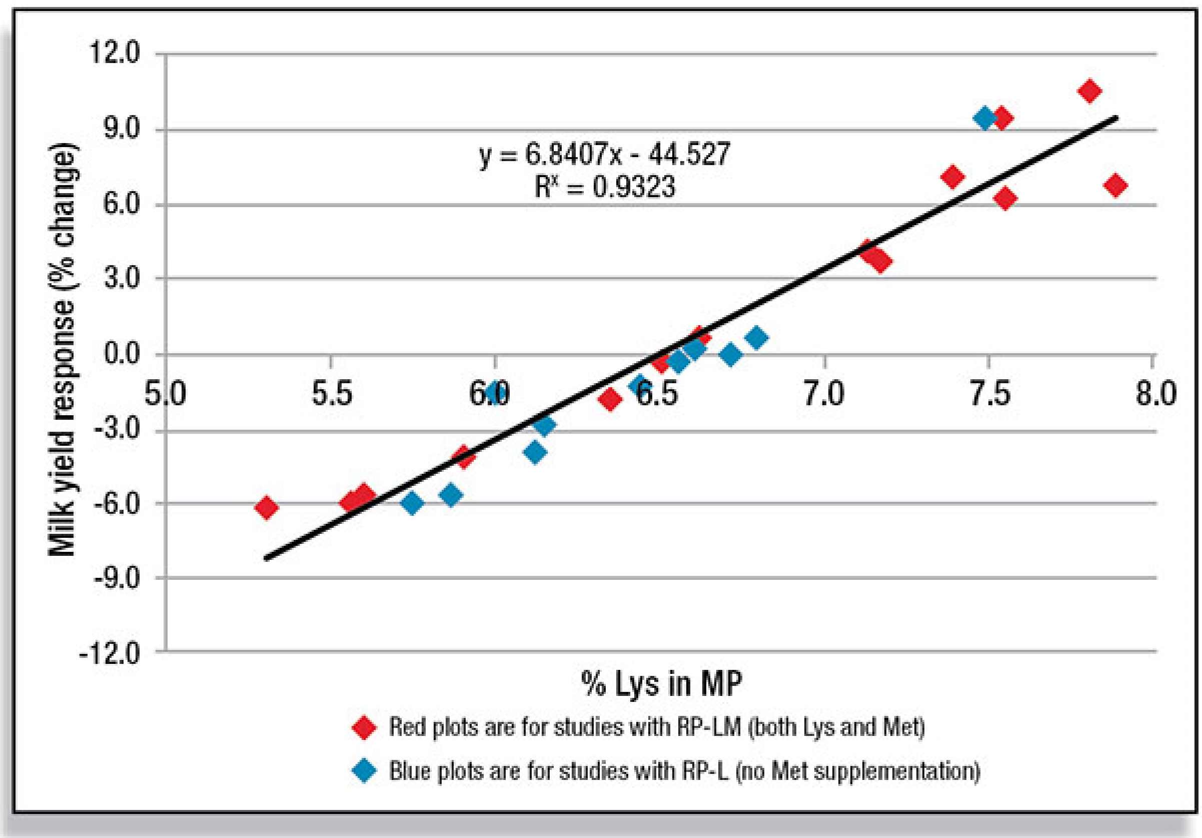
Control treatment pre- and post-calving;
Supplemental lysine pre- and control treatment post-calving;
Control treatment pre- and supplemental lysine post-calving;

Supplemental lysine pre- and post-calving

The results? The group receiving supplemental lysine pre-calving had a greater DMI after calving with a significantly reduced incidence of disease. The group that received supplemental lysine pre- and post-calving produced the most milk, with the control group producing the least amount of milk. Future discussions of amino acid requirements through transition will likely expand beyond methionine and lysine as the industry focus shifts to which of the remaining 10 essential amino acids is next limiting – which is next in holding back production?

## Lactating Animal

Supplementation with rumen-protected methionine (**RP-Met**) and lysine (**RP-Lys**) is now common. With methionine supplementation, we are seeing a trend to a 0.1 percent increase in milk protein for every 10 g of methionine supplementation when rations are methionine deficient. With lysine, a comparative newcomer, usage trends and recommended practices are emerging. Several published abstracts show an increase in milk flow from lysine supplementation. The figure below depicts the




abstracts resulting from research by Ajinomoto Heartland, Inc. company on our RP-Lys product. Several of the trials were conducted using only RP-Lys; others included RP-Met too.

As you can see, as the percentage of lysine in the metabolizable protein (percent Lys MP) increases, there is a constant increase in milk yield response. Many of these trials were done in early and high-lactation groups and resulted in a consistent response. From this dataset, we can derive that every 1 percentage point increase in Lys MP could result in a 6.8 percent increase in milk volume. How does this translate in the field? After observing and tracking several herds, the following lysine-usage practices are becoming apparent:

1. Adding amino acids to the ration; no other alterations.
2. Removing some blood meal or protein feed; adding RP-Lys.
3. Removing all blood meal; adding RP-Lys.

**Adding Lysine; No Other Alterations**

Adding lysine on top of the existing ration typically fails, based on our on-farm experience. Herds typically saw no response. Why? The diet likely was not limiting in lysine; consequently, the lysine added was metabolized into something else the cow needed, such as energy. While feed costs increased, no additional revenue was generated. Those herds that did sense a response had rations deficient in lysine (g less than 165).

**Remove Some Blood Meal or Protein Feed**

Removing some blood meal or protein feed typically provides cost savings thanks to the use of a synthetic form of lysine. Space also opens up in the diet for other, cheaper feeds. The ingredient changes that occur with this approach appear in the table below (expressed in pounds/cow per day). As you can tell, blood meal was reduced. In the new space, soybean products were increased for this 1,500-cow herd. The methionine source was adjusted to maintain the proper lysine-to-methionine ratio.

| Ingredient | Pre-supplementation | Post-supplementation |
|---|---|---|
| High bypass soybean meal | 1.32 | 1.42 |
| Blood meal | 0.90 | 0.54 |
| Soybean hulls | 0.07 | 0.28 |
| Rumen-protected lysine | 0.0 | 0.063 |
| Rumen-protected methionine | 0.035 | 0.04 |

Research recently completed comparing the models have indicated that lysine to methionine can be 2.7 to 1 for optimal results when utilizing a Cornell-based system and closer to 3 to 1 when utilizing a ration formulation system based on the National Research Council (NRC) recommendations. *Diet specifications* – The crude protein of this diet was reduced by 0.3 percent, the lysine was reduced by 2 g, methionine by 4 g, and the lysine-to-methionine ratio increased from 2.61 to 2.76. Some things stand out.

The total grams of lysine and methionine did decrease in this diet. This occurred because the lysine-to-methionine ratio was corrected, and the amount of lysine being provided by the blood meal is unknown. So the diet may have resulted in an increase in lysine that caused the production response. *Return on investment* – Positive results were obtained from both a cost savings and production standpoint. The diet cost decreased from $5.75 to $5.74. Milk yield increased from 80.5 pounds to 81.5 pounds. Butterfat percent increased from 3.58 percent to 3.7 percent, and protein increased from 3.03 percent to 3.13 percent. Milk urea nitrogen decreased from 10.4 to 9.2.

**Remove Animal Byproduct Feeds**

With the true methionine and lysine needs for the high-producing dairy cow being somewhat of a mystery, some nutritionists raised the question of what the next limiting amino acid is and whether we need to make sure we are meeting those requirements. Does this mean there is a need to keep some animal protein in the diet?

Research conducted by professor Alex Hristov at Pennsylvania State University has shown that at low crude proteins (13 to 14 percent), histidine likely becomes limiting. It would be unlikely to see levels that low in the field. However, environmental concerns could become an influencing factor here.

| Ingredient | Pre-supplementation | Post-supplementation |
|---|---|---|
| Expeller meal | 2.50 | 3.25 |
| Blood meal | 1.00 | 0.00 |
| Rumen-protected methionine | 0.01 | 0.02 |
| Rumen-protected lysine | 0.00 | 0.10 |
| Supplemental methionine with cherry flavoring | 0.05 | 0.06 |

This table (expressed pounds/cow per day) shows an example of a multi-thousand-head dairy whose nutritionist took the above approach. He felt consumer sentiment would prevent the use of animal proteins at some point. The extra diet space was filled with lysine supplementation and expeller meal. The methionine level was adjusted to maintain the proper ratios. *Diet specifications* – With this diet, crude protein decreased from 16.7 percent to 16 percent. The lysine grams went from 175 to 185, methionine from 59 to 61, and the lysine-to-methionine ratio changed slightly from 2.96 to 3.01. *Return on investment* – The return on investment was twofold. Price decreased from $7.29 to $7.02, and milk flow increased from 97.5 to 97.8 pounds. Butterfat increased from 3.5 to 3.6 percent, and protein increased from 3.03 to 3.05 percent. Milk urea nitrogen remained at 10.0.

## What we know – What we don't know

Do we know everything about amino acid balancing? We have come a long way. Trends and key principles for amino acid balancing are developing.

- Protein level targets are: prefresh 1,300 grams of MP, and fresh cow and high cow MP target at 98 percent of required model predictions.
- Provide sufficient rumen-degradable protein to maximize microbial yield.
- Confirm that your RP-Met and RP-Lys match the manufacturers' specifications.
- Make sure starch levels provide enough energy to drive the production of amino acids.
- Focus on prefresh cows too. Ample research shows methionine improves immune function. However, maintaining the proper lysine-to-methionine ratio is essential to ensure excess methionine is not converted to something else needed by the cow.
- Know your ration formulation system to know if your lysine-to-methionine ratio should be 2.7 to 1 or 3 to 1.

Amino acid balancing will be critical in the future if markets are down, up, or in between. Amino acids are essential nutrients. They directly impact animal production and performance.

## References

Bell, A. W., W. S. Burhans, and T. R. Overton. 2000. Protein nutrition in late pregnancy, maternal protein reserves, and lactation performance in dairy cows. Proc. Nutr. Soc. 59:119-126.

# SESSION NOTES