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Effective Use of Protein in Early Lactation Diets[1]

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Introduction

Dairy cows require essential amino acids, which are the building blocks of protein, for maintenance, reproduction, growth, and milk production. These amino acids must come from either microbial protein synthesized in the rumen or from dietary protein that is not degraded in the rumen. The quantity of amino acids required by the lactating cow depends on the level of milk production. As milk yield increases, amino acid requirements increase accordingly. Research suggests that lysine and methionine are the two amino acids that are often limiting or co-limiting for milk protein synthesis. To meet the minimum requirements, the ratio of lysine:methionine should be about 3:1 in the total diet. However, based on economics, the ratio may not be 3:1 when minimum needs are met with least cost diets.

Optimize Rumen Microbial Protein Synthesis First

Dietary protein consumed by the dairy cow contains true protein (amino acids) and nonprotein nitrogen (NPN). This feed protein is further categorized as rumen degradable protein (RDP) or rumen undegradable protein (RUP). RUP has sometimes been referred to as rumen by-pass protein or simply by-pass protein. The RDP is available for use by the rumen microbes to make microbial protein. The RUP escapes degradation in the rumen and flows to the abomasum, where the protein is hydrolyzed to amino acids, which then can be absorbed through the wall of the small intestine into the blood.

When rumen microbes break down the RDP, ammonia is produced. The microbes then use this ammonia along with a readily available carbohydrate energy source to form microbial protein. Microbial protein is the cellular protein of the rumen bacteria and protozoa. The quantity of microbial protein produced in the rumen is primarily dependent on the availability of fermentable carbohydrates, and available nitrogen but also dependent on RDP, rumen pH, the supply of amino acids and peptides, rumen turnover rate, feed particle size, and

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other factors.

If there is not enough fermentable carbohydrate available in the rumen to use the free ammonia, then rumen ammonia levels increase. The excess ammonia is absorbed through the wall of the rumen and travels to the liver, where it is metabolized to urea (which is less toxic than ammonia). It costs the cow 7.3 kcal of energy for each gram of ammonia that is converted to urea in the liver. This is energy that could have been used for milk production. Some of this urea circulates back to the rumen via saliva, but most is excreted through the urine. Urea levels can be evaluated by checking blood urea nitrogen or milk urea nitrogen (MUN). A discussion of how to interpret and use MUN lab results is presented later in this paper.

The microbial protein that is formed in the rumen is a very high quality protein in that it supplies those amino acids needed by the cow. This protein eventually leaves the rumen and moves to the abomasum, where the protein is hydrolyzed to amino acids. The amino acids are then absorbed through the wall of the small intestine into the blood. It is important to understand that when feeding dairy cows, we are also feeding the rumen microorganisms that form the microbial protein. Microbial protein can provide more than 60 percent of the total protein reaching the small intestine. A key to efficient feed utilization is to formulate rations that optimize microbial protein synthesis and also supply amounts of rumen undegradable or bypass protein needed for milk production.

Rumen Undegradable Protein is Needed

Rumen undegradable protein (RUP) is that portion of the crude protein that escapes degradation by rumen microbes, thus allowing the preformed amino acids in the feed to pass from the rumen to the small intestine for post-ruminal digestion and absorption. Dairy cows in early lactation producing large quantities of milk have a tremendous need for amino acids and may have the greatest need for RUP compared with other cows in the herd. While it is important to maximize microbial protein synthesis as the first step toward meeting this need, these early lactation cows cannot synthesize enough microbial protein to meet their requirement for amino acids. While a small amount of protein is available from body reserves as the cow loses weight in early lactation, this amount is minor compared with its requirements for protein. Thus additional rumen undegradable protein must be fed to meet the cow's amino acid needs.

In early lactation, 35 to 40 percent of the ration crude protein dry matter should be provided as RUP. You can determine the RUP percentage from the ration report by dividing the RUP percentage in the total ration dry matter (also listed as undegradable intake protein or UIP on some reports) by the percentage of crude protein in the total ration dry matter. For example, if your total ration formulation shows 18 percent crude protein and the undegradable portion of the dry matter is 7.2 percent, then the RUP is 40 percent of the crude protein.

You must also consider the RUP source and therefore its amino acid profile. Feeds have different levels of protein degradability, and the amino acids in the RUP vary and must complement the flow of amino acids from the microbial protein.

Lysine and Methionine

Lysine and methionine appear to be the two amino acids that are often limiting or co-limiting for milk protein synthesis. In other words, if these amino acids are not available in sufficient quantity when milk protein is being synthesized at the mammary gland, milk yield will be limited. The ratio of lysine to methionine found in ruminal bacteria, body tissue, and milk is very similar at about 3:1. Lysine is more likely to be low for diets in which corn or corn by-products supply most of the RUP, while methionine may be low in diets in which most of the RUP is provided by legume or animal-derived proteins. The ratio of lysine:methionine should be about 3:1 in the total diet when minimal requirements of these two amino acids are met.

Forage Type Affects RUP Needs

The type of forage being fed influences the need for RUP and should be considered when formulating diets.

Cows consuming diets formulated with different forages may respond differently to supplemental RUP. Cows fed diets with alfalfa or lush pasture may have a greater response to RUP than those fed corn silage-based diets. A possible explanation is that since alfalfa or lush pasture is high in crude protein, not as much supplemental protein, such as soybean meal, is needed to balance the ration for protein. However, the protein in alfalfa and lush pasture is very degradable in the rumen. Therefore, when undegradable protein sources are included to balance the RUP in these diets, a milk production increase often occurs. On the other hand, corn silage is much lower in crude protein. When corn silage-based diets are formulated, more supplemental protein, such as soybean meal, needs to be included to balance the protein in the ration. This supplemental protein added to corn silage diets may more nearly meet the RUP needs of the cow, and thus additional RUP may not result in the same response as when it is added to alfalfa- or pasture-based diets.

Should Urea be Included in the Early Lactation Diet?

Urea is a nonprotein nitrogen (NPN) source that contains about 45 percent nitrogen with a calculated crude protein equivalent of 281 percent (45 percent N x 6.25). Urea does not contain any amino acids and is generally useful only if rumen microbes can use the NPN plus fermentable carbohydrate to make amino acids. Therefore, urea additions to the diet are useful only if ruminal ammonia levels are so low that microbial growth is limited, which might occur only in low-protein diets. Urea is generally not beneficial in early lactation cow diets that contain high protein and adequate rumen degradable protein from natural feed sources.

Milk Urea Nitrogen Information Can be Useful

Milk urea nitrogen (MUN) measurement can be a useful diagnostic tool in evaluating the efficiency of diets. Dairy farmers in North Carolina and Virginia who are enrolled in the Dairy Herd Improvement program through the United Dairy Herd Improvement Association can have milk samples evaluated for MUN levels at the lab in Blacksburg, Virginia. MUN values are given as milligrams per 100 milliliters (mg/dl) and generally range between 10 and 18 mg/dl.

Milk urea nitrogen is an indicator of ammonia levels in the rumen. High MUN levels would suggest excess ruminal ammonia, perhaps due to overfeeding degradable protein and/or not enough fermentable carbohydrate, while low MUN levels would indicate low ruminal ammonia levels or insufficient dietary protein. For example, normal to high levels of MUN would suggest that urea should not be added to the diet because it would not be utilized. Also, there is an additional energy cost for excreting excess unusable ammonia, which can reduce milk production.

It has been suggested that milk urea nitrogen levels might provide guidance about proper ration formulation. In order to interpret MUN values for a herd, you must collect baseline MUN values over several months. Then, as you make ration changes, you can compare subsequent MUN values to this baseline. Collect milk samples for MUN analysis from all cows in the herd or at least from all cows within a group and from the same milking each time. In addition, to reduce variation, use the same laboratory to analyze all MUN milk samples from your herd.

Summary

- Dairy cows require essential amino acids, which are the building blocks of protein, for maintenance, reproduction, growth, and milk production.
- A key to efficient feed utilization is to optimize rumen microbial protein synthesis.
- Feed rumen undegradable protein to meet the amino acid needs of high-producing, early lactation cows. Generally, 35 to 40 percent of the ration crude protein dry matter should be RUP in early lactation diets.
- Lysine and methionine are the two amino acids that are often limiting or co-limiting for milk protein synthesis. The ratio of lysine:methionine should be about 3:1 in the total diet when minimal requirements of these two amino acids are met.
- The type of forage being fed, as well as the sources of supplemental protein, influence the need for RUP and should be considered when formulating diets.
- Urea is generally not useful in early lactation cow diets. Urea additions to the diet are useful only if ruminal ammonia levels are so low that microbial growth is limited. Urea may be useful in late lactation cow diets.
- Formulate rations that take into account rumen degradable protein (RDP), rumen undegradable protein (RUP), and available fermentable carbohydrate.
- Milk urea nitrogen measurement can be a useful diagnostic tool to help formulate diets that use protein and energy more effciently. Collect milk samples for MUN analysis from all cows in the herd or at least from all cows within a group and from the same milking each time. In addition, to reduce variation, use the same laboratory to analyze all MUN milk samples. Establish a baseline of MUN values for several months and compare future MUN values to it when evaluating changes in the diet.

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