Nutrition & Health: Beef

Optimizing rumen fiber digestion, microbial protein

A controlled-release urea source may be an effective tool for providing essential degradable nitrogen to rumen bacteria to ensure optimum fiber digestion and microbial protein production.

By VAUGHN HOLDER*

The value of ruminant production in the food chain comes from these animals’ ability to utilize fibrous energy sources as well as their ability to convert low-quality protein sources and non-protein nitrogen (NPN) into high-quality microbial protein.

These two aptitudes allow ruminants to utilize raw materials that would otherwise be unavailable in the feed chain, all while reducing the competitiveness and costs associated with higher-quality raw materials that are predominantly used in the monogastric animal feed and human food industries.

Therefore, in order to extract the maximum value from ruminant production systems, the ruminant must be provided with everything it needs to optimize both fiber digestion and microbial protein production. Fibrous feed materials generally have a high cellulose content. Cellulose is the most abundant organic polymer on Earth and represents a vast untapped energy supply.

Unfortunately, mammals are not capable of producing the enzymes necessary to degrade cellulose. However, some animals have a large fermentative compartment (i.e., the rumen) that houses a microbial population capable of degrading cellulose.

This facilitates the second advantage ruminants have, which is the opportunity to digest and absorb the microbes themselves that serve as a source of protein when they leave the rumen and move toward the glandular stomach and absorptive small intestine. This is also the reason why ruminants are able to use NPN.

Mammals cannot use NPN to produce proteins. The microorganisms in the rumen are able to utilize NPN to produce their own proteins, which then become available to the animals when they digest the microorganisms (microbial protein).

Microbial protein is the closest thing to the perfect protein for ruminants. It is produced in the rumen and, therefore, does not need qualities that allow it to “bypass” rumen fermentation.

Unlike most feed protein sources, microbial protein is highly digestible (80% or more), meaning that more of the protein is digested and absorbed by the animal.

Finally, the amino acid composition of microbial protein closely matches the amino acid requirements of the animal, and therefore, it is utilized by the animal very efficiently. In contrast, vegetable-based protein sources often have marked amino acid deficiencies (most notably for methionine and lysine) that reduce the efficiency with which the protein is utilized by the animal.

In order to optimize microbial protein production, the microbial population must be supplied with a sufficient amount of degradable crude protein to use as building blocks for the synthesis of the proteins of the microbes. As the microbial population grows, there are more microorganisms in the rumen to digest the diet effectively and more microorganisms that will eventually be used by the ruminant as microbial protein.

It is estimated that 50-80% of the crude protein requirement of ruminant bacteria is in the form of ammonia. Ammonia is supplied by the degradation of degradable feed proteins or NPN in the rumen.

The most commonly used NPN source in the diets of ruminants is urea due to its wide availability and low cost. However, urea is poorly utilized by the ruminant due to the extremely rapid degradation rate of urea in the rumen. The result is that a majority of urea that is fed to the animal is excreted via the urine.

To make efficient use of the nitrogen available in the rumen, the rate at which energy sources in the diet are fermented should be matched up with a protein source of similar degradation rate. Microorganisms have access to both energy and protein simultaneously, resulting in efficient microbial protein production (Figure 1). This can be achieved with urea by supplying energy sources that are high in soluble sugar content, such as molasses.

However, matching a ruminal protein source with the degradation of fiber and starches is a more difficult task. Starch and fiber degrade over a longer period of time and, therefore, require a nitrogen source that can maintain rumen ammonia concentration over this period.

When energy sources are fermented in low-nitrogen condition, the efficiency of microbial protein production is reduced. Additionally, reduced microbial protein means fewer microbes are available to digest the feed in the rumen, and this is one of the reasons why diets with a low degradable protein content tend to be less digestible.

Therefore, in order to maximize the efficiency with which feeds are utilized by the ruminant and to ensure optimal microbial protein production, it is essential to use the tools available to maintain rumen ammonia levels so that diet digestibility and microbial protein production can be optimized. One such tool is to use a controlled-release urea source (Optigen II) to ensure the supply of ammonia to rumen microbes throughout the day.

Figure 2 represents the ammonia concentration over time for cows fed a total mixed ration with and without controlled-release urea supplementation. The solid bar represents the ammonia concentration that is needed to meet the requirements of the rumen microbes. When the ammonia concentration dips below this level, the rumen microbes can no longer digest the diet or produce microbial protein efficiently. The blue curve represents a traditional diet, where rumen ammonia dips below the optimum level a few hours after feeding. This situation can be alleviated by using a controlled-release urea source that will maintain rumen ammonia levels throughout the day (yellow curve).

In conclusion, a controlled-release urea source significantly increased milk production by an average of 1 lb. per day and was likely driven by improved microbial protein production and diet digestibility due to the improved ruminal nitrogen supply.

Additionally, the incorporation of this urea product in the dairy cow diets was found to be economically favorable in the majority of circumstances.

As previously mentioned, the use of feed-grade urea can result in a large proportion of feed nitrogen being excreted into the environment via urine. This excreted nitrogen not only represents a loss of nutrients to cows but also can be a significant source of groundwater and air pollution.

Therefore, improving the efficiency with which ammonia is used to produce microbial protein not only increases the amount of protein available to cows but also reduces the amount of nitrous oxide pollution going into the environment.

The researchers found that the use of a controlled-release urea source significantly increased milk production by an average of 1 lb. per day and was likely driven by improved microbial protein production and diet digestibility due to the improved ruminal nitrogen supply.