



Beef Cattle Sciences

Beef Cattle Library

Protein Nutrition for Cattle¹

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Introduction

Feedstuffs contain several sources of true protein and non-protein nitrogen compounds. Proteins are large molecules that differ in size, shape, function, solubility, and amino acid composition. It is important to keep in mind that amino acids and not protein per se are the nutrients required by ruminants. Absorbed amino acids are vital nutrients for maintenance, growth, health, reproduction, and lactation, and are used mainly as building blocks for protein synthesis, as well as precursors for glucose and fatty acids synthesis. More specifically, amino acids are involved in tissue growth and repair, enzymatic activity, transport of molecules, genetic storage, immune function and cell differentiation. Therefore, supplying adequate amounts of amino acids is necessary to maintain the basal metabolism in ruminants. As previously mentioned, amino acids are the compounds required by the animals, but in the present article, the terms amino acid and protein nutrition will have and be used with the same meaning.

The goals of protein nutrition in ruminants are to provide minimum amounts of dietary crude protein (CP), but also adequate amounts of ruminally degraded protein (RDP) for optimal ruminal efficiency and microbial CP production. This article will provide some basic concepts associated with protein nutrition in cattle, aiming to help beef producers on detecting and designing nutritional strategies to enhance cattle performance and, consequently, productivity and profitability of beef operations

Measures of Protein

In contrast to energy, which cannot be quantified in absolute values (see BEEF040), feed content and cattle requirements for protein can be quantified in weight scales. Protein requirements for cattle are generally shown as pounds per day (i.e. lb. of CP/d), whereas protein concentration in the diet is described as % of diet dry matter (DM). An overview of the protein utilization by ruminants is presented in Figure 1.

- **Crude Protein (CP)** – Generally, CP concentration in feedstuffs is calculated using the nitrogen (N) concentration \times 6.25. This definition assumes that the average N concentration of a protein molecule is 16 %. Crude protein can be divided into ruminally undegraded protein (RUP) and RDP, which includes the non-protein N.
- **Natural (or true) protein** – Protein constituted by amino acids. It differs from non-protein N (see below), which does not have an amino acid profile but can be used as N source by ruminal microorganisms.
- **Non-protein N (NPN)** – Generally, this group is represented by nucleic acids and ammonia. The most well-known NPN compound used for cattle nutrition is urea. These compounds (NPN) are quickly degraded and converted into microbial protein by the rumen microorganisms. Two main factors support the use of NPN in cattle diets: 1) nutritionally, it adjusts the RDP amount in the

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diet, and 2) economically, NPN is less expensive compared with natural protein sources.

- **Ruminally Degraded Protein (RDP)** – After entering the rumen, this fraction provides a mixture of peptides, free amino acids, and ammonia that are used by microorganisms for growth and synthesis of microbial protein, which is the most important protein source for the ruminant and supplies the majority of amino acids entering the small intestine.
- **Ruminally Undegraded Protein (RUP)** – It is the second most important source of absorbable amino acids to the animal. It represents the protein that enters the intestine without any previous modification in the rumen, and then can be absorbed or not by the animal's intestine. Feeds containing high RUP concentrations include heat-treated soybean meal and cottonseed meal.
- **Endogenous CP** – Comprised by salivary and digestive secretions of ruminants, as well as sloughed epithelial cells.
- **Metabolizable Protein (MP)** – It represents the total amount protein absorbed by the animal, and it is supplied by the diet (RDP and RUP), microbial CP (MCP), and to a much less extent, endogenous CP.
- **Microbial Crude Protein (MCP)** – The most important protein source for cattle, supplying from 50 to 100% of the daily MP required by the animal. Microbial crude protein, which is mainly originated of bacterial source (about 90%), is the protein content of ruminal microorganisms that passes and are absorbed by the small intestine.

Previously, CP was the standard measure for protein analysis, but since 1989 MP is being used as standard protein measure mainly because of 2 factors: 1) more information is becoming available about the components of the MP system (MCP and RUP), which allows more accurate predictions of these factors, and 2) the CP system is based on an invalid assumption that all feedstuffs have an equal extent of protein degradation in the rumen, with CP being converted to MP with equal efficiency in all diets.

Importance of Protein for Cattle Production

Protein is important for many functions in the animal's body. With inadequate protein intake, vital organs and systems including mammary gland

activity, reproductive and immune functions do not operate properly.

More specifically for the ruminant, adequate protein level (> 7% CP) in the diet is required for maximal growth and activity of ruminal microorganisms, thus producing desired MCP amounts and maximizing ruminal fermentation. In contrast, feeding diets with protein content \leq 7% CP may result in impaired growth of ruminal microorganisms, fermentative functions, ruminal synthesis of MCP and amount of MCP absorbed in the small intestine. This is extremely important because MCP is the main protein source for ruminants, and inadequate protein levels may negatively impact ruminal function, performance, and subsequent productivity of the animal. Moreover, not only protein amount, but type of protein (RDP vs. RUP) in the diet is very important for the rumen microorganisms, given that RDP is used by rumen microorganisms for MCP synthesis, whereas RUP is absorbed in the small intestine without ruminal modification. The balance between these two types of protein is critical, and in diets where protein is not limiting microbial growth and ruminal functions, feeding RDP in excess may not further benefit, in fact may harm the ruminal environment and the animal.

- **Maintenance** – Adequate protein nutrition is required for maintenance of homeostasis, given that protein is required for several functions of the body. The maintenance requirements for protein are estimated in MP, which is the amount of amino acids available for absorption in the small intestine and comprises MCP, RUP, and endogenous CP.
- **Growth** – The amount of amino acids required for growth is dependent on several factors, including breed, sex, nutritional management, body condition score (BCS), production level, and animal age. Protein is required for adequate tissue accretion in ruminants, which is dependent on the quantity and/or balance of amino acids absorbed.
- **Lactation** – The cells within the mammary gland absorb amino acids to synthesize milk protein. Diets lacking adequate protein content may result in reduced milk protein yield. In addition, adequate protein supply in the diet is positively correlated with increased concentrations of milk lactose and fatty acids, and proper mammary gland activity.

- **Reproduction** – Protein intake must be in adequate level to optimize reproductive performance. Inadequate protein intake may cause estrus suppression, reduced conception rates, and weak newborn calves.
- **Health** – Immunoglobulins are proteins and defense molecules produced by the body after it encounters a foreign organism, such as a pathogen. Inadequate immunoglobulin production may cause defects in eliminating the foreign organism from the body, which may result in additional health issues.
- **Gestation** – Protein is required for adequate fetal formation. In addition, as previously mentioned, protein is required for proper production of immunoglobulins, which protect the newborn calf against diseases. Given that the calf does not have a preformed immune system, the immunoglobulins obtained upon colostrum consumption are the main defense mechanism for the newborn calf.

Feeding Protein to Cattle

Even though energy and protein are measured separately, maximum performance is obtained when requirements for both of these nutrients are met. However, many herds in the Western United States (including the state of Oregon) consume low-quality forage (< 7% CP), which does not meet protein requirements of these beef animals. Consequently, protein supplementation is required to achieve optimal productivity levels. The most common protein sources available in the Western U.S. include soybean meal and alfalfa hay. Although extremely important and needed, a general setback regarding protein supplementation is the cost associated with feed, labor, fuel, and equipments. Based on this rationale, one strategy adopted by many beef producers to reduce the costs of production is the infrequent protein supplementation. With infrequent supplementation, the total weekly amount of supplement is provided less frequently (for example, once every 6 days or 3 times weekly). Animal growth performance (growing steers and pregnant mature cows), forage intake, BCS, and ruminal parameters (nutrient digestibility, pH, volatile fatty acid, and ammonia production), are not impaired when cattle was supplemented once every 6 days compared with cattle provided supplements daily or once every 3 days (Bohnert et al., 2002) . This fact may be attributed to 2 features: 1) physiology: the unique N recycling pathway and ruminal function

characteristics of ruminants, and 2) management: reduced bunk and feed competition by providing a greater amount of supplement to the herd in a single time. Conversely, decreasing the frequency of energy supplementation (grain [corn] and fibrous-based [citrus pulp] supplements) impairs forage digestibility and intake, as well as performance and reproductive function (see BEEF040).

Another alternative to reduce the costs associated with protein supplementation is NPN utilization. As previously mentioned, NPN sources (i.e., urea) are cheaper on a CP basis when compared with true protein sources (i.e., soybean meal). However, caution must be adopted when feeding NPN to cattle: a) using the correct dosage and making sure it is well-mixed with concentrate or forage, and b) adequate energy sources (such as carbohydrates) available to the rumen microorganisms in order to maximize MCP. Many studies evaluated the effects of NPN utilization as a protein source for ruminants, including replacement heifers, mature cows, and growing steers. In summary, these studies reported that:

- **Growing cattle.** Replacing natural protein sources (cottonseed meal and feather meal) with urea negatively affected ADG and pregnancy rates of yearling beef heifers (Pate et al., 1990). Growing cattle have a substantial demand for MP to sustain tissue growth, therefore, these results can be explained by the greater supply of MP in heifers supplemented with natural protein sources compared with urea once the amino acid profile of urea is null. Similarly, growing steers have greater ADG if supplemented with natural protein compared with NPN sources (Karges et al., 1992).
- **Mature cows.** Supply of NPN (urea) to mature beef cows was evaluated by Cooke and Arthington (2008). These authors reported that cows in low plane of nutrition (BCS), grazing low-quality forages and offered a molasses-based supplement containing urea or a blend of cottonseed meal and feather meal had similar performance (BCS and body weight changes) and pregnancy rates throughout the winter, indicating that mature cows can rely on urea to satisfy their supplemental protein requirements.

Conclusions

Protein is required for vital body and productive functions, whereas inadequate protein nutrition leads to impaired growth, milk production,

and health. Forages grown in the Western U.S. often do not have adequate protein amounts, thus beef producers have to adopt supplementation programs to address this issue. Strategies to maintain cattle at optimal levels of productivity and reduce supplementation costs include infrequent protein supplementation and proper NPN utilization.

References

- Bohnert et al. 2002. *J. Anim. Sci.* 80:1629-1637.
- Cooke and Arthington. 2008. *Prof. Anim. Sci.* 24:264-268.
- Karges et al. 1992. *J. Anim. Sci.* 70:1957-1964.
- NRC. 1996. *Nutrient Requirements of Beef Cattle*. National Academy Press, Washington, DC.
- Pate et al. 1990. *J. Anim. Sci.* 68:618-623.

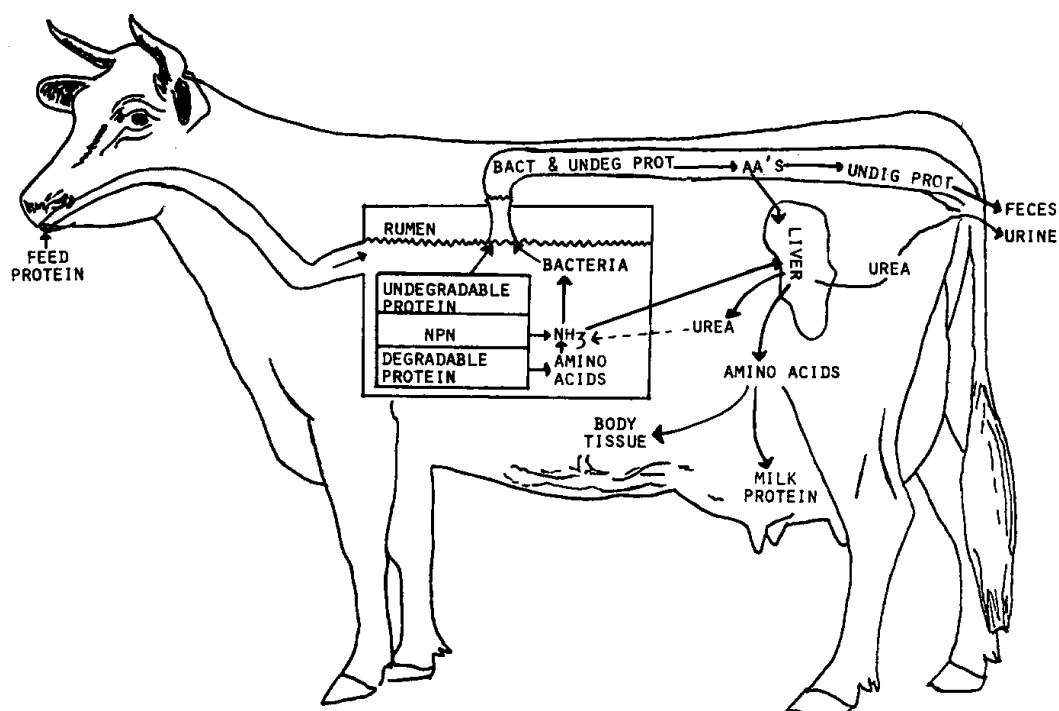


Figure 1. Pathway of protein utilization by the ruminant. NH_3 : ammonia; **Undeg. Prot.:** undegraded protein; **Undig. Prot.:** undigested protein; **NPN:** non-protein nitrogen.