

Protein and Energy Supplementation for Beef Cattle Grazing New Mexico Rangelands

Revised by Marcy Ward and Eric Scholljegerdes¹

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Providing supplemental nutrients to cattle grazing western rangelands is practiced commonly, and for good reason. Ruminants often are unable to consume enough nutrients from rangelands to fulfill their require-



ments for maintaining acceptable production levels. During such situations, supplemental feeding is necessary. Producers have many choices of commercial feed supplements and an unlimited number of options for developing custom supplements. Therefore, it can be difficult to decide which supplement type (energy or protein) best fits the goals of the livestock production system. A fundamental understanding of ruminant nutrition is also helpful in making these decisions. The objective of this publication is to clarify the relationship between protein and energy use by cattle, and to address protein and energy supplementation for grazing beef cattle.

GENERAL RUMINANT NUTRITION

Ruminants are different from pigs, horses, and humans in that they have a rumen in which ingested feedstuff is fermented before it reaches the stomach (called the abomasum in the cow). The rumen provides an optimal environment for the existence and growth of microorganisms. These rumen microorganisms break down, or digest, some of the feed that is ingested by the ruminant and use it for energy to support microbial growth. At the same time, rumen microorganisms release volatile fatty acids, which the ruminant animal uses as its major source of energy.

The bodies or cells of the rumen microorganisms eventually pass out of the rumen. Once they reach the small intestine, they can be digested by the ruminant. Because these cells contain approximately 50% protein, they contribute to the animal's protein supply. This symbiotic relationship between the ruminant and the microorganisms allows ruminants to use forage much more efficiently than non-ruminants. Additionally, this relationship adds to the complexity of predicting and effectively meeting the nutrient requirements of ruminant animals.

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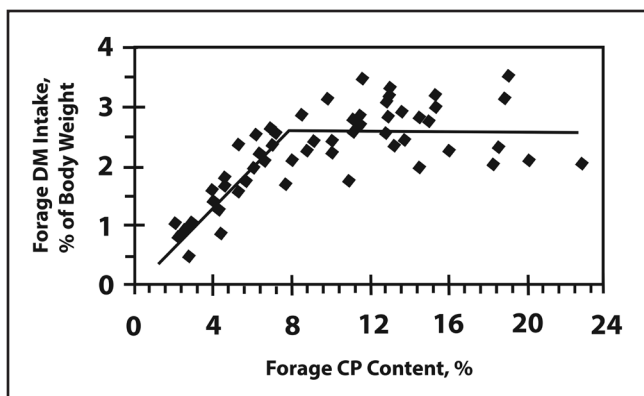


Figure 1. Relationship between forage crude protein content and forage intake.

Nevertheless, it is clear that ruminants must have energy to survive. However, it is the microorganisms in the rumen that must unlock (digest) the energy in the forage to make it available to the ruminant. To digest forage, the microorganisms must have nitrogen, which is primarily found in protein.

FORAGE SUPPLY AND COMPOSITION

The availability of forage and its chemical composition (primarily crude protein) are the first factors to consider in developing an effective range nutrition program. If the objective of a range nutrition program is to meet the nutrient requirements as economically and efficiently as possible, the first limiting nutrient must be identified and cost-effectively supplemented. Research has clearly demonstrated that with mature beef cows, the decision to feed a protein, energy, or combination supplement should depend on forage supply and protein content, and cow body condition.

DIET SELECTION

Cattle that are grazing native rangelands with a diverse plant population can be relatively selective about what they eat. This is most important when forage becomes dormant and the protein content declines. In general, cattle grazing dormant native range select a diet that is about 1.5 to 2 percentage units higher in crude protein content than the average of the standing forage in the pasture. For example, cows grazing native range in which the forage has an average protein content of 4% generally select a diet that is 5.5–6% crude protein.

However, cattle grazing less-diverse pastures, such as improved pastures containing only one or a few grass species, cannot be as selective, so the crude protein content in their diets is more similar to the average of the pasture's standing forage.

RUMINAL PROTEIN REQUIREMENTS

Rumen microorganisms synthesize an estimated 0.12 pounds of bacterial crude protein from 1 pound of total digestible nutrients (TDN, an estimate of energy supply to the animal; NASEM, 2016). An inadequate supply of protein from dormant forage can result in reduced microbial protein production, reduced forage digestion, and an unrecoverable loss of nutrients. Coupled with an unbalanced supply of metabolizable nutrients for the animal tissues, these changes can lower forage intake and cattle performance. Providing a balanced, or in some instances an unbalanced, supply of nutrients to the rumen is a key to obtaining the desired intake and production response. The relationship between protein and energy illustrates the importance of ensuring that the nutrient supply in the rumen does not limit microbial activity.

PROTEIN SUPPLEMENTATION

Forage Intake

Daily energy intake is the primary factor limiting cattle performance on forage diets. In many instances with warm-season perennial forages, and possibly with cool-season perennial forages at advanced stages of maturity, there is an inadequate supply of crude protein, which effectively limits energy intake. An example of the relationship between crude protein content of forages and forage intake is presented in Figure 1. Intake declines rapidly as forage crude protein falls below about 7%, a relationship attributed to a deficiency of nitrogen (protein) in the rumen, which hampers microbial activity.

If the forage diet contains less than about 7% crude protein, feeding a protein supplement generally improves the energy and protein status of cattle by improving their forage intake and digestion. For example (Figure 1), at a crude protein content of 5%, forage intake is about 1.6% of body weight, while at 7% crude protein, forage intake is 44% higher at 2.3% of body weight.

Improved forage intake boosts energy intake, which demonstrates why correcting a protein deficiency is usually the first supplementation priority. For example, Table 1 shows the estimated impact of protein supplementation on energy status. Forage intake increased 30% in response to a modest amount of protein supplement (0.18% of body weight), resulting in a 49% increase in TDN (energy) intake by the cow.

The crude protein content of some forages must drop to about 5% before intake declines. However, intake of other forages may decline when forage crude protein drops to 10%. Part of the variation can be attributed to differences in nutrient requirements of the

cattle, with the remainder attributed to inherent differences among forages that provide differing proportions of nutrients to rumen microorganisms. Response of intake to a single nutrient such as crude protein would not be expected to be similar among all forages.

Sources of Supplemental Protein

Supplemental protein is available in many forms. Feed-stuffs and formulated feeds containing from less than 10% crude protein to more than 60% crude protein are available. To complicate things further, crude protein may come from a natural protein source, a non-protein nitrogen source, or a mixture of the two. An additional consideration may be the ratio of ruminally degradable protein to escape protein (commonly referred to as bypass protein).

Crude Protein Content of Supplements

Research has established a correlation between supplement protein content and total forage intake when forage quality drops below 7% crude protein (Table 2; Heldt, 1998). If the objective is to optimize intake and digestion of low-quality forages, it is easy to see that supplements should contain more than 30% crude protein, although supplements containing less than 30% crude protein may yield a slight enhancement in forage intake.

Escape Protein Versus Ruminally Degradable Protein

Escape protein is protein that is not degraded in the rumen and thus escapes to the small intestine where it can be digested. Plant-based protein concentrates, such as cottonseed meal and soybean meal, generally contain 55–70% ruminally degradable protein and 30–45% escape protein.

In a situation where forage is abundant, forage protein content is low, and the objective is to stimulate or sustain forage intake, ruminally degradable protein is the first priority because the rumen microorganisms need additional nitrogen. Feeding cattle a supplemental protein source with high “escape” potential may not stimulate ruminal activity, so forage intake and performance response to supplementation may be less than if the cattle were fed a supplement with a higher proportion of ruminally degradable protein.

Research results favor using ruminally degradable protein sources over escape protein sources for cattle consuming low-protein forages. When forage supply is abundant but low in protein, it is recommended that 60–70% of the supplemental protein be ruminally degradable, and that the total diet contain 0.11–0.13 pounds of ruminally degradable protein per pound of TDN.

Table 3 represents an example of a calculation for estimating the amount of supplemental ruminally degrad-

Table 1. An Example of the Impact of Protein Supplementation on the Energy Status of a 1,000-pound Cow

	Unsupplemented	Supplemented	Change, %
Forage crude protein, %	5	5	
Forage TDN ^a , %	45	45	
Supplement crude protein, %		42	
Supplement TDN, %		76	
Supplement intake, lb	0	1.8	
Forage intake, lb	16	20.8	+30
Total daily intake, lb	16	22.6	+41
Total diet crude protein, %	5	7.9	
TDN intake, lb	7.2	10.7	+49

^aTDN = total digestible nutrients

Adapted from McCollum (1997).

Table 2. Average Improvement in Low-quality Forage Intake in Response to Various Crude Protein Concentrations

Supplement Protein Content, %	Improvement in Forage Intake Above Unsupplemented, %
Less than 15	3
15–20	10
20–30	21
Greater than 30	44

Source: Heldt (1998).

able protein needed by an 1,100-pound cow grazing an abundant supply of low-quality forage (5.5% protein). In this example, the deficiency in ruminally degradable protein is approximately 0.45 pounds. It would take approximately 2 pounds per day of a 40% protein cottonseed meal-based supplement to fulfill this requirement. When feeding a traditional 20% range cube, feeding rates would need to be doubled (4 pounds per day)

However, there is typically a diminishing return to protein supplementation. The first increment of supplemental protein typically accounts for a proportionally larger percentage of the potential improvement in performance than do later increments. Research has determined that the majority of the improvement in performance results from providing supplemental protein equivalent to about 30–40% of the actual protein deficiency.

In the example in Table 3, although the cow needs 0.45 pounds of supplemental ruminally de-

Table 3. Sample Calculation of Daily Supplemental Protein Needed to Meet the Ruminally Degradable Protein Requirement of an 1,100-pound Cow Grazing an Abundant Supply of Low-quality Forage	
Component	Quantity
Forage intake, lb ^a	20
Forage TDN ^b , %	55
Forage CP ^c , %	5.5
Ruminally degradable protein, % of CP	55
Diet TDN, lb	11
CP in selected diet, % ^d	7.5
CP in the diet, lb	1.5
Ruminally degradable protein requirement, lb ^c	1.27
Diet ruminally degradable protein supply, lb	0.82
Supplemental ruminally degradable protein needed, lb	0.45
^a Estimated at 1.8% of body weight per day. ^b TDN = total digestible nutrients ^c CP = crude protein ^d Estimated at 2 percentage units above pasture average. ^e Based on NASEM (2016) guidelines (ruminally degradable protein required as 65% of total CP intake).	

gradable protein, the majority of the potential response to supplementation generally can be achieved by providing only about 65% of the estimated deficiency. This would be equivalent to about 0.3 pounds of ruminally degradable protein and about 1.5 pounds of a 40% protein cottonseed meal-based supplement, or 3 pounds of a 20% range cube product. If performance remains suboptimal at this quantity, then it may be necessary to provide additional protein.

If supplying ruminally degradable protein does not improve production, then supplying escape protein may help. This is especially true for beef cattle with high protein requirements due to lactation, growth, or lactation and growth combined. Often, forages contain 12–20% crude protein that is highly degradable in the rumen (ruminally degradable protein >70% of crude protein). The high degradability of the forage protein may result in a relatively large portion of the nitrogen being absorbed across the rumen wall without being converted to microbial protein. This absorbed nitrogen cannot be used completely by the animal. Therefore, it may be necessary to provide a supplement that is high in escape protein (50%) to meet the animal's protein requirements. In some instances, cattle grazing high-quality forages that are fed a supplement high in escape protein have improved both their forage intake and weight gain.

Research conducted at NMSU has evaluated the effects of escape protein fed to cows and heifers in marginal body condition grazing dormant New Mexico rangelands (4–6% crude protein). A series of several studies demonstrated that escape protein supplements may play a role in energy metabolism and reproductive efficiency in young cows grazing native forage. Supplements containing anywhere from 20–50% undegradable intake protein (UIP) as part of the crude protein source resulted in less weight loss post calving, shorter post-partum intervals, and improved milk production and pregnancy rates (Hawkins et al., 2000).

It is important to note that supplements with high concentrations of escape protein can be expensive. A good alternative is supplementing with dried distillers grain. This economical byproduct from the ethanol industry typically tests at 28–30% crude protein, of which approximately 70% is considered bypass protein. Research has shown improvement in body weight and pregnancy rates, and reductions in post-partum intervals in young cows (Engle et al., 2008; Martin et al., 2007). The same result may also be achieved by providing more of a protein supplement that has a lower concentration of escape protein such that the same amount of escape protein is provided, or by providing a supplement with a higher energy content.

Urea Usage in Protein Supplements

At times, non-protein nitrogen in the form of urea can be a less-expensive source of protein. Urea is used directly by rumen microorganisms as a source of nitrogen and is completely ruminally degradable. However, this source of nitrogen is very unpalatable and should be used in moderation. Because urea has a much higher concentration of nitrogen than protein, the protein equivalence of urea is 290% (1 pound of urea is equivalent to about 2.9 pounds of protein based on nitrogen content).

Research conducted at Kansas State University indicates that urea can be used to reduce protein supplement costs without causing negative effects on performance—as long as not more than 25% of the ruminally degradable protein in the diet is supplied by urea (Woods, 1997). Including higher concentrations of urea in protein supplements reduces the supplement palatability and ultimately suppresses intake and animal performance. If urea-containing protein supplements are fed less frequently than every other day or are fed to lactating cows, urea should not supply more than 15% of the ruminally degradable protein in the supplement.

ENERGY SUPPLEMENTATION

When performance is limited by energy intake and forage protein content is not limiting microbial activity, the best option is to increase the energy intake directly with an energy supplement (low protein, high energy) if it is not possible to correct the short supply of energy by reducing stocking rates. Typically, energy supplements are less expensive per unit than protein supplements, but the response to energy supplementation can be variable and difficult to predict.

Substitution with Energy Supplements

A common frustration with feeding energy sources is the “substitution effect.” This occurs when the supplemental feed substitutes for forage by reducing forage intake. One of the main concerns when providing energy supplements to grazing beef cows is the starch content of the supplement. Research has shown that when high-starch supplements (such as corn, grain sorghum, wheat, or barley) are fed to cattle consuming forages (especially when protein is deficient), forage intake and digestion are often suppressed, ultimately reducing the energy derived from the basal forage diet. Therefore, to truly “supplement” energy, highly digestible fiber sources (such as soyhulls, wheat bran, wheat middlings, or corn gluten feed) are generally most desirable.

Any time substitution occurs, the energy intake of the animal may not increase to the desired level because of a concomitant reduction in forage intake. As a general rule, 1 pound of an energy-dense feed reduces forage intake by 0.5–1 pound. The substitution rate depends on forage protein content, level of protein in the supplement, type of energy sources, and feeding rate. The substitution rate increases as forage protein content increases, the rate decreases as the level of protein in the supplement increases, and the rate tends to increase as supplement intake increases.

Feeding high levels of hay can also result in substitution. As the amount of hay fed daily increases, forage intake from the pasture decreases because fill from the hay replaces fill from the pasture.

Sources of Supplemental Energy

To sustain or possibly improve the current level of forage intake but increase the total daily energy intake, a supplement with a moderate level of protein will be required to ensure an adequate supply of ruminally degradable protein. Additionally, the quantity of high-starch feedstuffs should be limited. Instead, energy supplements should consist of highly digestible fiber sources. However, using highly digestible fiber sources for energy supplementation does not eliminate the possibility of substitution.



Feeding Rate

Feeding low-protein, energy-dense supplements at rates of less than 0.3% of body weight per day (3.3 pounds/day for an 1,100-pound cow) typically has no negative impact on forage intake and may even yield an increase. However, as the feeding rate increases, forage intake generally begins to decline due to substitution, so performance may not increase as rapidly as expected because the decrease in energy supplied by the grazed forage diet often is overlooked.

FREQUENCY OF SUPPLEMENTATION

Feeding frequency (daily versus three times per week versus once per week) can affect animal response. Feeding smaller amounts of protein or energy supplements more frequently decreases the potential for negative impacts on forage intake. However, research conducted at NMSU that evaluated infrequent delivery of high-protein supplements revealed no significant reductions in heifer performance when supplemental protein was fed one time per week as compared to three times per week (Table 4). Additionally, transportation and labor costs were reduced by approximately 60%. NMSU researchers have also demonstrated that heifer performance (weight gain and conception rate) significantly declined when the frequency of energy supplementation was decreased from daily to twice per week (Table 5).

Table 4. Comparison of Supplementing the Same Amount of Cottonseed Cake (41% CP ^a) to Yearling Heifers Once Weekly Versus Three Times Weekly During the Winter-spring Dormant Season of Two Consecutive Years				
Component	Year 1		Year 2	
Times fed/week	1	3	1	3
Amount fed/feeding, lb/hd ^b	6.9	2.3	10.5	3.5
Protein fed/feeding, lb/hd	2.8	0.95	4.3	1.43
Number of heifers/treatment	43	40	27	18
Average initial weight, lb	495	495	502	491
Average daily gain, lb	0.50	0.47	0.34	0.37
Conception rate, %	93	90	89	89
^a CP = crude protein ^b hd = head Adapted from Wallace and Parker (1992).				

Table 5. Comparison of Grain Cubes for Energy Supplementation of Yearling Heifers Either Daily or Twice Weekly for 156 Days During the Winter-spring Dormant Season		
Component	Grain Cube (9.4% CP ^a)	
Times fed/week	2	7
Supplement fed, lb/hd ^b	6.4	1.8
TDN ^c fed/feeding, lb/hd	5.34	1.52
Average daily gain, lb/day	-0.03	0.14
Conception rate, %	68	94
Supplement cost, \$/hd	\$23	\$23
^a CP = crude protein ^b hd = head ^c TDN = total digestible nutrients Adapted from Wallace and Parker (1992).		

EXAMPLE SITUATIONS

Situation 1: Forage supply is abundant and protein content of the native range is 5% or less.

In this situation, cows should be able to select a diet that is 6.5–7% crude protein. Therefore, supplemental protein is necessary and should increase forage intake and possibly forage digestion. A small quantity (0.5–1 pound/day) of high-protein supplement (>30% protein) is typically the most economical supplement to use in this situation. If cows are ma-

ture, the protein in the supplement should be around 55–70% ruminally degradable. Most commercial feed supplements (i.e., range cubes) on the market today will meet these benchmarks. At this rate, both the nitrogen requirements of the rumen microorganisms and the protein requirements of the cow should be fulfilled. However, if the protein content of the native range is less than 4%, a larger quantity of supplemental protein may be necessary.

Situation 2: Forage supply is limited and protein content of the native range is above 5%.

In this situation, cows should be able to select a diet that is adequate in protein content (7%), meeting the needs of both the rumen microorganisms and the beef cow. This situation is not uncommon during droughts. Often, the most cost-effective solution to this problem is to lease pasture in another area so that stocking rates can be reduced to levels where forage supply is not limiting and very minimal supplementation is necessary.

However, a producer may want to provide supplemental energy to the cows instead. This is a situation where a low-protein, high-energy supplement is required. If the goal is to supplement without substitution, then a highly digestible fiber source is desirable. Providing energy in the form of a supplement high in soyhulls, wheat bran, or wheat middlings may yield the desired results if supplementation does not exceed about 4 pounds per day. Supplementation above that level probably will result in some substitution. Additionally, energy supplements of this nature should be fed at least every other day.

In cases of limited forage supply, the goal may be to provide additional energy and reduce the amount of forage harvested from the range by the cows. In this situation, an energy substitute would be beneficial. Substitution can typically be accomplished by feeding large quantities (>0.5% of body weight) of hay or any other digestible energy source (such as corn or grain sorghum).

Situation 3: Forage supply is unlimited and protein content of the native range is above 5%.

Cows should have enough available energy and should be able to select a diet that is adequate in both energy and protein content (7%), meeting the needs of both the rumen microorganisms and the beef cow. This is an ideal scenario that requires no intervention.

Situation 4: Forage supply is limited and protein content of the native range is less than 5%.

Cows are not able to select a diet that is adequate in energy or protein content. Unfortunately, this situation is relatively common throughout the western United States. In this case, a combination supplement ranging from 20–30% crude protein should be provided. Although alfalfa hay generally does not fit in this range, it may be a

practical alternative if it is provided at 5–10 pounds per day. However, as forage supply decreases, the protein content of the supplement should also decrease so that the energy content of the supplement can supply more energy per unit of supplement. Additionally, as the protein content of the supplement decreases, the per-unit cost of supplement should decrease.

SUMMARY

NMSU's Corona Range and Livestock Research Center (CRLRC), located near Corona, NM, has been monitoring forage quality on the ranch for over 20 years. Figure 2 is a graph that depicts crude protein content of the forage in good-, average-, and low-quality years compared to a heifer's protein requirement.

Even in good years, protein supplementation is warranted when forage is dormant. If heifers are run in the same pasture as mature cows, supplementation strategies should be designed to meet the needs of the heifer because her requirements are greater (10% CP vs. 8% for cows).

Supplemental feeding of protein and/or energy to grazing beef cattle in the western United States is practiced commonly and accounts for a significant economic input into beef production enterprises. It is important that money is not spent unnecessarily on nutrients that are not limiting animal performance. More specifically, it is important that when protein is deficient, producers do not spend money feeding cattle supplemental energy that can be supplied by the forage in the pasture, or spend money on high concentrations of protein in a supplement when energy is deficient.

When forages are low in protein, providing supplemental protein can increase both forage intake and digestion, ultimately improving both the protein and energy status of the cow. When forage supply is low and

energy limits the performance of the cow herd, providing supplemental energy in the form of highly digestible fiber should increase the cow's energy intake while minimizing the potential for substitution.

However, if the forage supply is so low that it would be desirable to reduce the amount of forage harvested daily by the cow herd, then the herd should be fed high levels of energy; the source of energy (starch vs. fiber) would be of less importance.

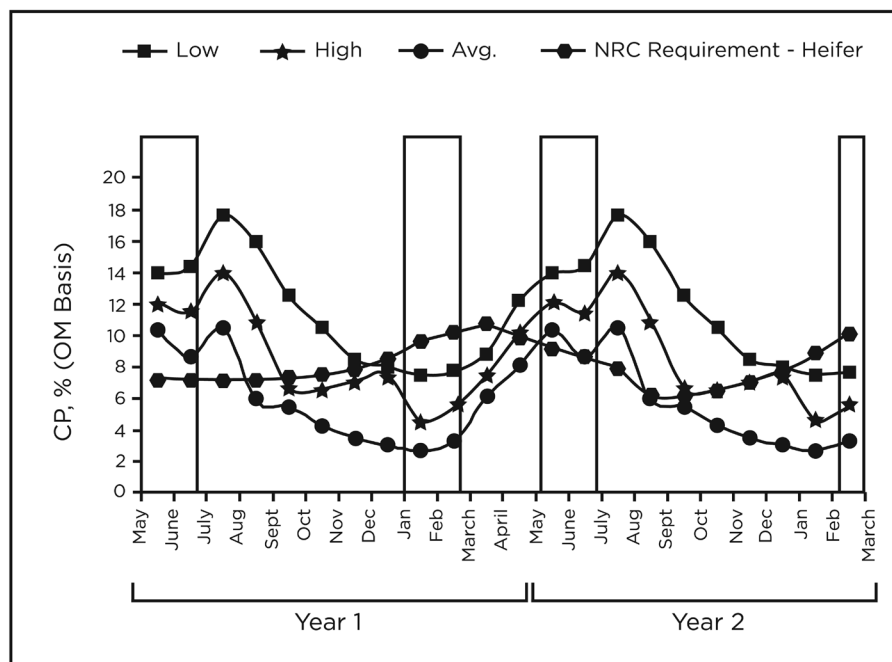


Figure 2. Protein content of CRLRC forage versus heifer protein requirements over time. (Data provided by Dr. Eric Scholljegerdes, Department of Animal and Range Sciences, NMSU.)

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