# Protein and Energy Supplementation to Beef Cows Grazing New Mexico Rangelands

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# Protein and Energy Supplementation to Beef Cows Grazing New Mexico Rangelands[1]

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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 adequately fulfill their requirements 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 the development of 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 also is helpful in making decisions of this nature. The objective of this publication is to clarify the relationship between protein and energy use by cattle, and to address protein and energy supplementation to grazing beef cows.

## GENERAL RUMINANT NUTRITION

Ruminants are different from pigs 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. The 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 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 percent 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 do nonruminants. Additionally, this relationship adds to the complexity of predicting and effectively meeting the nutrient requirements of ruminant animals.

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 percent generally select a diet that is 5.5 to 6 percent 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.

[1]Portions of this publication were adapted from McCollum, F.T. 1997. Supplementation strategies for beef cattle. Texas Agric. Ext. Service. Publ. B-6067.

### Ruminal Protein Requirements

The National Research Council (1996) proposed that ruminal microorganisms synthesize about 0.13 pounds of bacterial crude protein from 1.0 pound of total digestible nutrients (TDN; an estimate of energy supply to the animal). 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 (fig. 1). Intake declines rapidly as forage crude protein falls below about 7 percent, 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 percent crude protein, feeding a protein supplement generally improves the energy and protein status of cattle by improving their forage intake and digestion. For example (fig. 1), at a crude protein content of 5 percent, forage intake is about 1.6 percent of body weight, while at 7 percent crude protein, forage intake is 44 percent higher at 2.3 percent of body weight.

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

The crude protein content of some forages must drop to about 5 percent before intake declines. However, intake of other forages may decline when forage crude protein drops to 10 percent. 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 present differing proportions of nutrients to rumen microbes. 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. Feedstuffs and formulated feeds containing from less than 10 percent crude protein to more than 60 percent crude protein are available. To complicate things further, crude protein may come from a natural protein source, a nonprotein 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*).

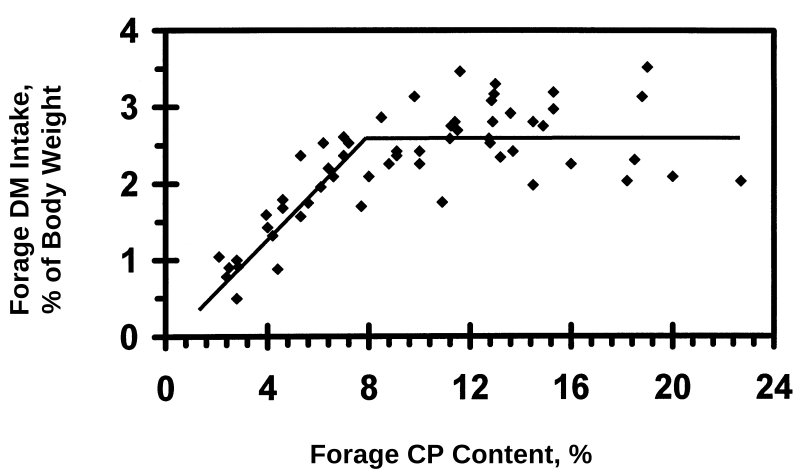


**Figure 1. Forage dry matter (DM) intake relative to the forage crude protein (CP) content.**

**Table 1. An example of the impact of protein supplementation on the energy status of a 1,000-pound cow (adapted from McCollum, 1997).**

| | 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 |

[a]TDN=total digestible nutrients.

## Crude Protein Concentration of Supplements

In a recent review (Heldt 1998), supplements were categorized by crude protein content to compare the effects of supplementation on the intake of low-quality forage (less than 7 percent crude protein) (table 2). 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 percent crude protein, although supplements containing less than 30 percent 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, were it can be digested. Protein concentrates of plant origin, such as cottonseed meal and soybean meal, generally contain 55 to 70 percent ruminally degradable protein and 30 to 45 percent 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 microbes 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 to 70 percent of the supplemental protein be ruminally degradable, and that the total diet contain 0.11 to 0.13 pounds of ruminally degradable protein per pound of TDN.

**Table 2. Average improvement in low-quality forage intake in response to various crude protein concentrations (Heldt 1998).**

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

Table 3 represents an example of a calculation for estimating the amount of supplemental ruminally degradable protein needed by an 1,100-pound cow grazing an abundant supply of low-quality forage (5.5 percent protein). In this example the deficiency in ruminally degradable protein is approximately 0.6 pounds. It would take approximately 2.5 pounds per day of a 40 percent protein, cottonseed meal–based supplement to fulfill this requirement.

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 demonstrated that the majority of the improvement in performance results from providing supplemental protein equivalent to about 30 to 40 percent of the actual protein deficiency.

In the example in table 3, although the cow needs 0.6 pounds of supplemental ruminally degradable protein, the majority of the potential response to supplementation generally can be achieved by providing only about 65 percent of the estimated deficiency. This would be equivalent to about 0.4 pounds of ruminally degradable protein and about 1.6 pounds of a 40 percent protein, cottonseed meal–based supplement. 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 to 20 percent crude protein that is highly degradable in the rumen (ruminally degradable protein > 70 percent 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 percent) to meet the animal’s protein requirements. In some instances, cattle grazing high-quality forages and fed a supplement high

**Table 3. Sample calculation of 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[e] | 1.4 |
| Diet ruminally degradable protein supply, lb | 0.8 |
| Supplemental ruminally degradable protein needed, lb | 0.6 |

[a]Estimated at 1.8% 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 NRC (1996) guidelines (ruminally degradable protein required is 13% of TDN intake).

in escape protein have improved both their forage intake and weight gain.

Research conducted at NMSU has evaluated the effects of escape protein supplements (50 percent ruminally undegradable protein) fed to cows and heifers in marginal body condition grazing dormant New Mexico rangelands (4 to 6 percent crude protein). This research has demonstrated that escape protein supplements (50 percent escape) may reduce losses in body condition during lactation by repartitioning more energy toward fat stores instead of toward milk production (fig. 2). In turn, the females have more available energy to direct toward reproduction.

NMSU researchers also have evaluated the use of escape protein in supplements fed to developing heifers grazing New Mexico rangelands. The heifers used in these trials were from four different calf crops between 1994 and 1998. Each year heifers were fed one of two protein supplements (approximately 40 percent protein) while grazing lightly stocked pastures during the winter-spring dormant season. The heifers received a supplement that was either high (50 percent) or low (30 percent) in escape protein content. The results of the four years of data revealed a 15 percent higher overall pregnancy rate (7 to 23 percent) among heifers fed the high escape protein supplement (personal communication with D. Hawkins, associate professor, NMSU Department of Animal and Range Sciences, July 1999).

It is important to note that supplements with high concentrations of escape protein can be expensive. The same result may 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

Nonprotein nitrogen (NPN) in the form of urea is generally the least 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 percent (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 percent 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 percent 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,

**Figure 2. Research conducted at NMSU has demonstrated improved pregnancy rates among heifers fed protein supplements that contain 50 percent escape protein.**

**Figure 3. Protein supplements can be delivered as infrequently as once a week without significantly affecting animal performance. However, when providing energy supplements, best results are achieved when the supplement is delivered daily.**

**Figure 4. When forage supply is limited and stocking rate cannot be sufficiently reduced, it is best to use highly digestible sources of fiber to supplement energy.**

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." Substitution occurs when the supplemental feed substitutes for forage by reducing forage intake. One of the chief concerns when providing energy supplements to grazing beef cows is the starch content of the supplement. Research has demonstrated that when high-starch supplements (such as corn, grain sorghum, wheat, and 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, and corn gluten feed) generally are most desirable.

Anytime 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 to 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 also can 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 assure 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 (fig. 4). 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 percent 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.

**Table 4. Comparison of supplementing the same amount of cottonseed cake (41% CP*) to yearling heifers once weekly versus three times weekly during the winter-spring dormant season of two consecutive years.**

| Component | Year 1 | | Year 2 | |
|---|---|---|---|---|
| Time fed/week | 1 | 3 | 1 | 3 |
| Amount fed/feeding, lb/hd** | 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 |

*CP=crude protein

**hd=head

Adapted from Wallace and Parker 1992

**Table 5. Comparison of grain cubes for energy supplementing yearling heifers either daily or twice weeklyfor 156 days during the winter-spring dormant season.**

| Component | Grain Cube (9.4% CP*) | |
|---|---|---|
| Time fed/week | 2 | 7 |
| Supplement fed, lb/hd** | 6.4 | 1.8 |
| TDN fed/feeding, lb/hd | 5.34 | 1.52 |
| ADG, lb/d | -.03 | .14 |
| Conception Rate, % | 68 | 94 |
| Supplement Cost, $/hd | $23 | $23 |

*CP=crude protein

**hd=head

Adapted from Wallace and Parker 1992

## FREQUENCY OF SUPPLEMENTATION

Feeding frequency (daily versus three times per week versus once a 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, fig. 3). Additionally, transportation and labor costs were reduced by approximately 60 percent. NMSU researchers also have 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).

## SITUATIONS

### Situation 1

Forage supply is abundant and protein content of the native range is 5 percent or less.

In this situation, cows should be able to select a diet that is 6.5 to 7 percent crude protein. Therefore, supplemental protein is necessary and should increase forage intake and possibly forage digestion. A small quantity (0.5 to 1.0 pounds/day) of high protein supplement (> 30 percent protein) typically is the most economical supplement to use in this situation. If cows are mature, the protein in the supplement should be around 55 to 70 percent ruminally degradable. 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 percent, 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 percent.

In this situation, cows should be able to select a diet that is adequate in protein content (7 percent), meeting the needs of both the ruminal 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 no less frequently than 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 percent 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 percent.

Cows should have enough available energy and should be able to select a diet that is adequate in both energy and protein content (7 percent), meeting the needs of both the ruminal 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 percent.

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 to 30 percent crude protein should be provided. Although alfalfa hay generally does not fit in this range, provided at 5 to 10 pounds per day, it may be a practical alternative. However, as forage supply decreases, the protein content of the supplement also should decrease so that the energy content of the supplement can be evaluated to 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

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.

## LITERATURE CITED


Heldt, J.S. 1998. *Effect of various supplemental carbohydrate sources on the utilization of low-quality tallgrass-prairie forage.* Ph.D. dissertation. Kansas State University, Manhattan, Kansas.

McCollum, F.T. 1997. *Supplementation strategies for beef cattle.* Texas Agric. Ext. Service. Publ. B-6067.

Moore, J.E. and W.E. Kunkle. 1995. *Improving forage supplementation programs for beef cattle.* In: Sixth Annual Florida Ruminant Nutrition Symposium, Gainesville, Fla. p 65-74.

NRC. 1996. *Nutrient Requirements of Beef Cattle (7th ed).* National Academy Press, Washington, D.C.

Wallace, J.D. and E.E. Parker. 1992. Range supplements—what we have learned. New Mexico Cattle Growers' Short Course. p 20-27.

Woods, B.C. 1997. *Effect of inclusion of urea and supplement frequency on intake, digestion, and performance of cattle consuming low-quality, tallgrass prairie forage.* M.S. thesis. Kansas State University, Manhattan, Kansas.

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