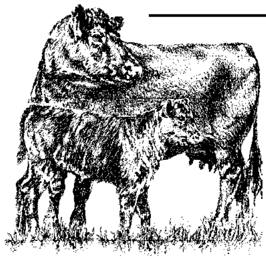

Western Beef Resource Committee

Cattle Producer's Library

Nutrition Section CL317

Fundamentals of Supplementing Low-Quality Forage

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One of the distinct advantages of ruminants over other livestock species is their ability to effectively utilize forages as a source of nutrients for maintenance and production (growth, lactation, and reproduction). As a result, most cattle will spend their entire lives, except for the final 4 to 6 months in the feedlot, grazing standing forages and/or consuming hay.

Forage quality is usually sufficient to support normal levels of production early in the growing season. However, as forages mature they increase in fiber content and decrease in protein and digestibility. Consequently, low-quality forages often require some form of supplementation to maintain desired levels of production.

A reoccurring problem faced by beef producers is when, and with what, to supplement low-quality forage. The answer depends on many variables including (1) physiological state of cattle, (2) nutrients required for a desired level of production, (3) nutrient content of the forage, and (4) quantity of forage available.

The nutrient requirements of beef cattle are well documented and readily available to producers. Thus, a supplementation program can be defined as a program that provides the difference between the nutrients required by the cattle and the nutrients provided by the low-quality forage.

Protein Supplementation

Protein is normally the first limiting nutrient in low-quality forage diets and, therefore, is usually the most beneficial nutrient to supplement when an adequate quantity of forage is available. Fig. 1 compares the approximate digestible protein requirements of beef cows with digestible protein derived from range forage.

Because protein is required by both the animal (for normal growth and production) and ruminal microorganisms (for microbial growth and ruminal digestion), a protein deficiency can severely depress animal performance and productivity. Most responses to protein supplementation are observed when the crude protein (CP; percentage nitrogen x 6.25) content of the forage is less than 6 to 8 percent.

Type of Protein Supplement

Protein supplements can be classified as natural (animal or plant origin) or non-protein nitrogen (NPN; such as urea and biuret). In addition, CP is divided into degradable intake protein (DIP) and undegradable intake protein (UIP).

Degradable intake protein is broken down within the rumen by ruminal microorganisms to yield ammonia and amino acids that they use to stimulate ruminal fermentation and synthesize microbial protein (the main source of protein for grazing ruminants). Undegradable

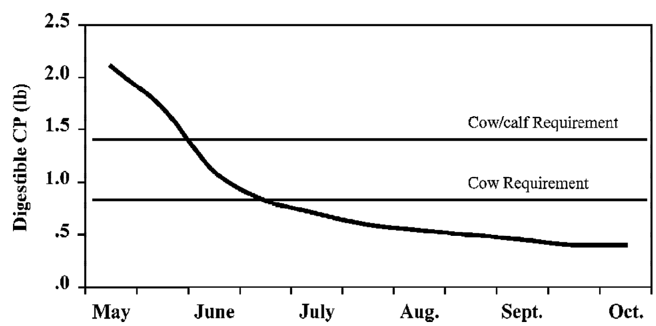

Fig. 1. Approximate digestible crude protein required by spring calving cows with calves and dry cows and the amount obtained from range forage.

Portions of this article were obtained from data compiled by the Western Region Coordinating Committee on improvement of forage utilization by ruminants in sustainable production systems in the western region.

intake protein is not broken down by ruminal microorganisms and "escapes" ruminal degradation.

Because ruminants have the ability to recycle nitrogen back to the rumen, absorbed UIP not utilized for growth or production can be converted to urea and used as DIP (albeit inefficiently). Therefore, microbial protein and dietary UIP are the protein sources available for use by the ruminant. The DIP and UIP content of some common protein sources is listed in Table 1.

When forage availability is not limiting, the first priority in designing a protein supplement should be meeting the ruminal requirement for DIP (10 to 12 percent of total digestible nutrient intake; TDN intake). The reasons for this include:

1. Ruminal microorganisms can use DIP to produce microbial protein (high quality protein source).
2. Sources of DIP are normally less expensive than UIP sources.
3. DIP may improve ruminal fermentation and digestion.
4. UIP supplementation of low-quality forage does not appear to elicit substantial improvements in beef cattle performance compared with DIP.

Once the ruminal requirement for DIP is met, however, additional DIP will not increase microbial protein production or enhance ruminal fermentation. Therefore, if additional protein is still required to obtain a desired level of production, it must be supplied by UIP.

Table 1. Chemical composition* of some potential feed ingredients for use as sources of supplemental protein for low-quality forages.

Protein source	CP (%)	% of CP DIP	% of CP UIP	TDN (%)	ME Mcal/kg
Brewers grain	26	41	59	70	2.53
Canola meal	41	68	32	69	2.49
Coconut meal	22	62	38	64	2.31
Corn gluten meal	47	38	62	84	3.04
Cottonseed meal, mech	44	57	43	78	2.82
Cottonseed meal, sol-41% CP	46	57	43	75	2.71
Cottonseed meal, sol-43% CP	49	57	43	75	2.71
Distillers grain	30	45	55	90	3.25
Soybean meal-44	53	80	20	84	3.04
Soybean meal-49	50	65	35	87	3.15
Soybean whole	40	65	35	94	3.40
Sunflower meal	26	38	62	65	2.35
Urea	291	100	0	0	0.00
Alfalfa hay					
Vegetative	22	86	14	64	2.31
Early bloom	20	84	16	62	2.24
Mid bloom	17	82	18	60	2.17
Full bloom	13	77	23	56	2.02
Wheat middlings	18	77	23	83	3.00
Tall fescue hay	9	67	33	56	2.02
Meadow hay	13	77	23	60	2.17

*CP = crude protein; DIP = degradable intake protein; UIP = undegradable intake protein; TDN = total digestible nutrients; ME = metabolizable energy.

The dietary nitrogen to sulfur ratio should also be considered when formulating a protein supplement. This is especially important when DIP makes up a large portion of the supplement.

Ruminal microorganisms use sulfur to synthesize methionine and cystine (sulfur-containing amino acids), which are used in the production of microbial protein. It has been suggested that ratios ranging from 10:1 to 15:1 can increase the intake and digestibility of low-quality forages compared with ratios greater than 15:1.

Physical Form of Protein Supplement

The most common sources of supplemental protein are derived from oilseed byproducts such as soybean meal and cottonseed meal (Table 1). These sources of supplemental protein offer several advantages, including a high concentration of crude protein (e.g., soybean and cottonseed meal consistently have at least 50 and 45 percent CP, respectively) and energy densities similar to cereal grains. Thus, while we usually consider these supplements as protein sources, they also provide significant energy contributions. However, these feed sources are sometimes expensive.

In the Pacific Northwest and Intermountain West, alfalfa hay or cubes are often the supplement of choice because of competitive pricing and easy accessibility to the supplements. In general, alfalfa provides the same benefits as other protein supplements when fed on an equal crude protein basis. Alfalfa hay may have an added advantage because it is easily transported and handled by ranchers, whereas oilseed supplements may require additional equipment, such as feed bunks and storage bins.

While alfalfa is a versatile protein supplement with easy application to many beef production scenarios, producers should be careful to make sure the energy requirements are met and body condition reserves are adequate during winter feeding periods. While alfalfa can effectively meet CP requirements in rations with low-quality roughages, alfalfa does not have the caloric density of the oilseed meals or other byproduct feeds (Table 1).

Another potential supplement for low-quality forages is high-quality grass hay. Based on beef cattle performance, high quality grass hays (≥ 12% CP) have been adequate supplements to low-quality forages when compared to alfalfa and oilseed byproducts (CP basis).

Intake Response

The most consistent response to protein supplementation of low-quality forages is increased intake (frequently by as much as 25 percent or more). Also, protein supplementation either slightly increases (< 6%) or does not affect the digestibility of low-quality forages. As a result, the total quantity of digestible nutrients (including protein and energy) available to the animal for maintenance, reproduction, lactation, and growth is increased. This is based on the premise that forage quantity is not limiting, therefore, allowing the animal to increase forage intake.

Performance Response

Protein supplementation of beef cattle consuming low-quality forage normally results in increased performance. Mature cows lose less weight and/or body condition during the winter grazing or feeding period when supplemented. As a result, protein supplementation tends to promote greater reproductive efficiency and calf weaning weights. Also, protein supplementation of calves consuming low-quality forage has consistently increased daily gains compared with non-supplemented controls.

Natural vs. NPN Supplementation

Ruminal microorganisms can effectively use NPN as a nitrogen source in the production of microbial protein; however, research has suggested that sources of natural protein may be superior to sources of NPN when used as CP supplements to low-quality forage. Studies have shown that the CP equivalent from urea and biuret (NPN sources) is often used at an efficiency of approximately 70 to 100 percent compared with CP from natural sources. Consequently, cows supplemented with natural protein have often gained more (or lost less) weight and had improved performance compared with cows consuming NPN supplements with similar levels of CP.

An obvious advantage of NPN sources over natural proteins is cost. Sources of NPN are usually less expensive than sources of natural protein (on a CP basis). However, concerns of NPN sources include the inefficient use of protein and the potential for urea toxicity. Therefore, caution should be used in developing and feeding an NPN supplement to beef cattle consuming low-quality forage.

Most cost-effective supplements will contain both NPN and natural proteins. Generally, NPN sources should not provide more than one-third of total supplemental CP fed to cattle consuming low-quality forage.

Optimal Protein Concentration

The CP content of a protein supplement can also influence the intake and digestibility of low-quality forage. The greatest increases in intake and digestibility are usually observed when a protein supplement contains 25 to 35 percent CP. Consequently, a protein supplement should normally contain a minimum of 25 percent CP.

The exception to this is forage supplements (alfalfa and high quality grass hay). Supplementing low-quality forage with good quality alfalfa (15 to 21% CP) or grass hay (12 to 15% CP) has been shown to be as effective as oilseed-meal-based supplements containing greater than 25 percent CP. However, this is only true if alfalfa and/or grass hay is fed in greater amounts so that the total amount of CP supplied is equal.

Energy Supplementation

There are circumstances wherein the energy requirements of young or lactating cattle cannot be met with low-quality forage, even with adequate protein supplementation. In addition, overstocking or drought can cause forage quantity to be restricted and limit energy intake by grazing cattle. These situations will require supplemental energy, in addition to protein, to meet desired levels of production.

This can be expensive, however, and may decrease forage utilization (energy supplementation of low-quality forages has generally been reported to decrease forage intake and digestibility). As a result, cattle tend to use energy supplements as a replacement or substitute for forage instead of supplementing it.

In most situations, 1 pound of an energy-dense feed will reduce forage intake by .5 to 1 pound. However, this rate is dependent on forage quality, amount of energy supplement fed, concentration of CP in the supplement, and type of energy source.

Type of Energy Supplement

Most energy supplements consist of grain (starch based) or fermentable fiber. Common grain supplements include corn, sorghum-grain, barley, oats, and wheat. Sources of fermentable fiber include soybean hulls, wheat middlings, beet pulp, and corn gluten feed.

Supplementing low-quality forage with grain can depress forage intake and digestibility by increasing the proportion of starch digesting bacteria and decreasing the number of cellulose (fiber) digesting bacteria within the rumen. Results have been variable, but supplementation with grain at .4 percent of body weight has generally not depressed the intake and digestibility of low-quality forage by beef cattle.

The maximum level of grain supplementation believed to minimally affect forage intake and digestibility is .8 percent of body weight. At levels greater than .8 percent of body weight, forage intake and digestibility can be greatly depressed. Therefore, caution should be used when formulating grain supplements intended for use with cattle consuming low-quality forage.

Supplementation of low-quality forage with sources of fermentable fiber has generally not decreased forage intake and/or digestibility as much as grain-based supplements. Favorable results have been seen with fermentable fiber when supplemented at a rate of .2 to .8 percent of body weight. In addition, performance data suggest that sources of fermentable fiber are at least equal to corn in energy value when supplemented to grazing livestock. Another positive aspect of fermentable fiber is a potential reduction in the negative associative effects often observed with grain feeding (e.g., acidosis).

Providing energy supplements at greater than .5 percent of body weight should be discouraged if the goal is to optimize beef cattle production from low-quality forage. However, in periods of low forage availability (drought, overstocking, etc.), energy supplementation becomes a viable means of extending a limited forage supply.

Protein to Energy Ratio

The concentration of CP in the supplement can also influence the effect of supplemental energy on forage intake and digestibility. This is due to the ruminal microbes requirement for a balanced supply of energy and protein. Research with cattle has demonstrated that increasing the energy content of low protein supplements (< 25% CP) can decrease the intake and digestibility of low-quality forage, while increasing the energy content of high protein supplements (> 25% CP) has little effect on forage intake and digestibility.

The dietary ratio of TDN to CP (TDN:CP) is often used to evaluate the energy and protein balance of forage diets. A ratio of about 4:1 is assumed to maximize forage intake. In addition, forage intake is negatively associated with the TDN:CP ratio. As the TDN:CP ratio becomes greater than 4:1, ruminal fermentation is depressed (because of excess digestible energy compared with CP) which decreases forage intake.

In Table 2, cottonseed meal and corn are compared as supplements to low-quality forage using the TDN:CP ratio. Most research suggests protein supplementation may be needed when the TDN:CP ratio is greater than 6.1 to 8:1.

Rumen Fermentation Modifiers

Rumen fermentation modifiers, as the name implies, alter microbial fermentation in the rumen. Their purpose is to increase the quantity of energy obtained from feed consumed by cattle. Products currently approved for use in beef cattle consuming a forage diet include Rumensin® (monensin), Bovatec® (lasalocid), and GAINPRO™ (bambermycin). Each of these products is commonly used to improve the feed efficiency and/or weight gain of cattle on pasture. Gain of steers and heifers on pasture has been improved by about .15 to .20 pound per head daily when one of the ruminal fermentation modifiers mentioned previously is included in a supplement.

Table 2. Use of the total digestible nutrient (TDN):CP ratio in choosing a supplement to improve utilization of low-quality forage.[1]

	Supplement	
Item	**Cottonseed meal**	**Corn**
Forage CP, %	5	5
Forage TDN, %	50	50
Supplement CP, %	46	9
Supplement TDN, %	75	88
Forage TDN:CP	10	10
Supplement TDN:CP	**1.63**	**9.78**
Target TDN:CP of diet	4 to 6	4 to 6
Supplement choice[2]	✔	

[1]Adapted from Texas Agriculture Extension Service Bulletin #B-6067.
[2]Only cottonseed meal could lower the TDN:CP ratio to the target range of 4:1 to 6:1.

Each of the products has various label claims and is available in different forms of feed. In addition, the cattle producer who uses these products has the responsibility of using them properly. This includes: (1) using the feed additive for its intended purpose, (2) following the feeding guidelines and any warning statement on the label, and (3) storing the feed properly.

Conclusion

Numerous supplements are available that will provide protein and energy to beef cattle consuming low-quality forage. The “ideal” supplement is one that best fits the target animal’s nutritional needs, is easiest to handle and present to the target animals, and is the most economical to purchase and feed. Protein appears to be the most beneficial supplement for beef cattle consuming low-quality forage (<6 to 8% CP), yet energy content or density may be important depending on body condition status and subsequent reproductive success of the herd.

In contrast to energy supplements, supplemental protein improves beef cattle performance primarily through increased forage intake and digestibility, thereby increasing the amount of total digestible nutrients available to the animal. Also, supplements containing natural protein are sometimes superior to those containing NPN. However, the differences in response can be minimized by blending sources of NPN and natural proteins. A supplement consisting of a blend of NPN and natural proteins can offer economic advantages over supplements based entirely on natural protein.

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